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NOVEMBER 2002

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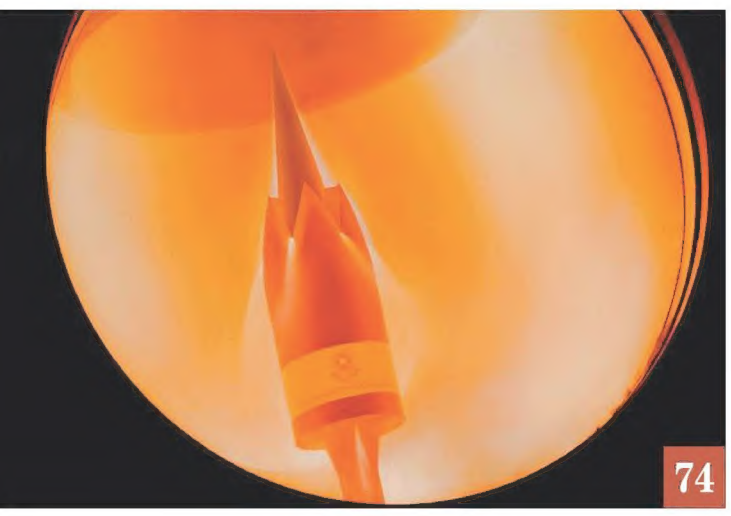

AIR&SPACE

Smithsonian

October/November 2002
Volume 17 • Number 4

100TH ISSUE

FEATURES

Cover:
The F-104 was more star than fighter during its 1960s tour as a trainer for the Aerospace Research Pilot School at Edwards Air Force Base, California.

DEPARTMENTS

100 YEARS AFTER THE FIRST

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Build It and They Will Browse

In early 1994, scientists at the National Air and Space Museum's Center for Earth and Planetary Studies (CEPS) opened a Web site to provide public access to collections and research information. By 1995, more information from the rest of the Museum had been added, and the National Air and Space Museum public Web site was born.

The quantity and the quality of information available on the Web site has grown rapidly, with visits growing even faster: In February 1997, the site logged roughly 800,000 hits, but by last May, the number had reached almost 12 million.

New technologies are being integrated into the Web site—as well as in Museum exhibitions—to create a more rewarding educational experience. In addition to providing basic information for Museum visitors, the Web site offers educators, students, researchers, and enthusiasts interactive learning aids such as "Black Wings: African American Pioneer Aviators" (*www.nasm.si.edu/blackwings*) and the "Exploring the Planets Cyber Center" (*cybercenter.si.edu*). Restoration work in the Garber facility in Suitland, Maryland, can be viewed via the Web cam there (*www.nasm.si.edu/garber*). Online visitors can also sign up for Museum memberships with the National Air and Space Society (*www.nasm.si.edu/membership*) or add names to the National Aviation and Space Wall of Honor (*www.nasm.si.edu/wallofhonor*).

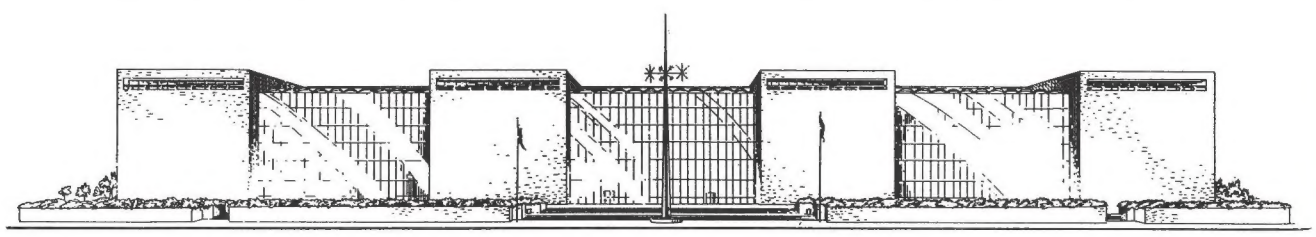
The Web site also offers information and experiences that even a visit to the Museum can't provide: a virtual tour of the 1997–1999 exhibition "Star Wars: The Magic of Myth" (*www.nasm.si.edu/StarWars*), imagery and information for aircraft and spacecraft that are not on display, unique finding aids and resources from the Museum Library and Archives, and the results of current research projects, such as the CEPS staff's recent discovery of what were once lakes and floods on Mars. Finally, online visitors can learn about the Steven F. Udvar-Hazy Center, a new exhibition facility opening in 2003, and view photos of its construction (*www.nasm.si.edu/udvarhazycenter*).

Web-based technologies within exhibitions offer an exciting means to enhance visitors' experiences. A display in "Exploring the Planets" shows new images from the Mars Odyssey spacecraft, and the next generation of interactive kiosks in "Explore the Universe" will feature continually updated astronomical discoveries.

Some big changes coming to the site include a new design along with new historical resources, educational activities, and access to the Museum's collections information database. And as the Steven F. Udvar-Hazy Center is completed, the Web site will provide information about the facility and powerful new tools to help visitors plan a trip there.

The National Air and Space Museum showcases the history of aviation and space exploration, focusing on the innovation and technology that have made the dream of flight possible. With the help of Internet technology, the Museum reaches beyond the National Mall to inspire and educate an ever-growing online audience in the United States and around the world. So stop by *www.nasm.si.edu* to see what's new and watch us grow.

—J.R. Dailey is the director of the National Air and Space Museum.



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Web site: www.airspacemag.com

Air & Space/Smithsonian (ISSN 0886-2257) is published bimonthly by Smithsonian Business Ventures, MRC 951, P.O. Box 37012, Washington, DC 20013. Editorial offices: MRC 951, P.O. Box 37012, Washington, DC 20013. Circulation and advertising offices: 420 Lexington Ave., New York, NY 10170. Canadian publication agreement no. 40039324.

Subscription Prices: U.S. and possessions: $24 a year payable in U.S. funds. Canada and all other countries: add $6.00 (U.S. funds) per year. Eighty-five percent of dues is designated for magazine subscription. Current issue price: $3.95 (U.S. funds). Back issue price: $7.00 (U.S. funds). Periodical postage paid at Washington, DC, and additional mailing offices.

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LETTERS

Hey, I Know That Glider...

Growing up in Philadelphia in the 1950s, I dreamed of designing a small helicopter propelled by two wingtip ramjets. On a school trip to Buck Hill Falls in the Pocono Mountains in the winter of 1952, I spotted a CG-4 glider in a farmer's field somewhere near Bethlehem, Pennsylvania. Perhaps it was the same glider that Joshua Stoff discovered ("A Waco's Happy Ending," Aug./Sept. 2002). I later returned and the farmer gave me permission to cut out some aluminum tubing I needed to make the rotor mast and frame of my dream craft. I still have the rotor mast, but regrettably, I can't find the rest of the tubing.

Harrison Wehner
Machipongo, Virginia

I grew up in Bethlehem, Pennsylvania, just eight miles from Nazareth. On the front porch of our house, we had what the family simply called the glider bench. I couldn't figure out why everybody called it that—it certainly didn't glide. It wasn't until I was in high school or college that I realized that the bench was from a glider aircraft, specifically a Waco CG-4. Did our glider bench come from the same airframe that Mr. Stoff writes about?

I don't know what became of the bench, but I think my mother left it there when she sold the old house in 1969.

David M. Moll
Fresno, California

Joshua Stoff replies: That probably was our glider, Mr. Wehner. No hard feelings, though; we were able to replace the tubing. As for Mr. Moll's bench, I doubt it's from our CG-4. The farmer we bought our glider from had saved all four original benches in his barn loft. However, let me know if yours ever turns up. I know of a couple of museums that would like to get hold of one.

In the summer of 1943, I was a 16-year-old Civil Air Patrol cadet attending a cadet camp in Indianapolis, Indiana. The Army's I-Troop Carrier Command was stationed at nearby Stout Field. We cadets would watch, fascinated, as low-flying C-47s would practice "snatch pickups" of Stout's CG-4. The C-47 would make a steep approach at 180 mph and, using a hook, grab the glider's 350-foot nylon tow rope, which had been suspended from two poles. As the C-47 climbed, the CG-4 would accelerate to 120 mph within six seconds, climbing at an extreme angle until it was above the C-47. After release at about 2,000 feet, the CG-4 pilot made a 180-degree left turn to the downwind leg, then another 180-degree left turn onto final approach. The pilots may have washed out as fighter or bomber pilots, as your article states, but, using the CG-4's spoilers, they were able to land within a 10-foot line time after time, all day long.

You can imagine our thrill when we were told that we would be given a CG-4 snatch pickup ride before we left camp. The next day we boarded the CG-4. At first there was silence; then we heard the low sound of the C-47. It grew louder and louder until the airplane passed overhead. We felt a slight jerk; then suddenly the plexiglass windshield of the glider was shattered. The tow rope had been stretched so taut it had broken, and when it fell back, it broke the windshield.

I was sure our ride was over, but the ground crew quickly attached a new tow rope and the C-47 made another approach. This time when the C-47 grabbed the rope, we felt a violent acceleration. Even though I was wearing a safety belt, I was thrown rearward. Then the CG-4 leveled off, and I could see the C-47 ahead and below us. The rest of the flight was uneventful, though the wind and noise coming in through the broken windshield were intense.

William Cowdin
Burbank, California

Phoenix Reborn

"Air War in the Falklands" (Aug./Sept. 2002) explained so much about a war very few of us have studied.

One interesting detail not included is that the cruiser the Argentinians named *General Belgrano* was originally the USS *Phoenix*, one of the few ships to survive the attack on Pearl Harbor.

Ed Watson
Westfield, Massachusetts

Another Side to the Spooky Story

"The Birth of Spooky" (June/ July 2002) states that the military did not adopt Lieutenant Gilmour McDonald's 1942 proposal to use side-firing weapons for anti-submarine warfare. I was a Navy radioman and port waist gunner on a Martin Mariner in early 1945, and we trained in both air-to-air and air-to-sea

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firing. I vividly recall standing at the open waist hatch as the pilot made pylon turns around a sea-borne target; the only things that kept me in the plane were the spade grips on my free-mounted machine gun and centrifugal force.

Our crew never got to put that training into practice in anti-submarine patrols, but I would guess that other crews did.

J. Warren McFarland
Winter Springs, Florida

Too Many Pounds, Too Little Potential

Responding to "The Plane With No Name" (Feb./Mar. 2002), Mark Anderson conjectures: "Had Grumman's F-111B been allowed to evolve along with the U.S. Air Force, it might have fulfilled other missions besides the Phoenix-missile-equipped interceptor role" (Letters, Aug./Sept. 2002). Having worked for Grumman from 1972 to 1992 in the technical publications department and as assistant corporate historian, I know that the company was selected as a subcontractor to develop and build a navalized version of the land-based F-111A. This iteration wasn't really a Grumman airplane. Only seven F-111B prototypes were built before both Grumman and the Navy realized that the aircraft was simply too big and too heavy to operate from aircraft carriers. Because the weight problem was unsolvable, no amount of further development, such as giving the aircraft a deep-strike or electronic countermeasures role, would have helped it play a role in naval aviation. This deficiency gave rise to the F-14 Tomcat, probably the best multi-role aircraft the U.S. Navy ever had.

William C. Barto
Bay Shore, New York

Still Idling

As a professional pilot and lifelong airliner fan, the subject of grounded aircraft is personal to me ("The Unemployment Line," Aug./Sept. 2002). My hard-earned job resides in one of those parked 727s. I was flying one on September 11, and it was retired from our fleet the following month, two years sooner than planned. I want to fly one of those glorious jets again, but likely won't anytime soon, as I have been furloughed.

Name Withheld on Request

Corrections

Aug./Sept. 2002 "Nights Over North Vietnam," Above & Beyond: The coauthor of *Buddha's Child* is Marvin Wolf. We regret misspelling his name.

Apr./May 2002 "Barfology": The Army's reconfigurable simulator can be changed from an AH-64, not a UH-64.

Moments & Milestones: The National Aeronautic Association requires that airplane speed and distance records and the airship duration record be broken by only one percent.

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All letters selected for publication will be edited. We regret that we cannot acknowledge every letter personally.

Running up History

For five years now, Ken Hyde has thrown a picnic at his bucolic Meadows Aerodrome in Warrenton, Virginia, home of the Wright Experience. The barbecue, held in conjunction with the Virginia Aeronautical Historical Society summer party, has always been a big draw, but for hardcore prop-heads, the truly magnetic attraction as of late is the ceremonial Running of the Engine: the sole original working Wright engine, a 1910 Vertical Four, serial no. 20, of 33 horsepower, which once powered a floatplane.

On a steamy July afternoon, machinist Greg Cone dollies the engine from the shop to the driveway. He is wearing denims, an American flag bowtie, and a handlebar mustache, and is toting a Halon extinguisher. "The engine is safe," he says. "This is in case I catch fire."

Hyde established the Wright Experience and Discovery of Flight Foundation, he says, to re-create the brothers' research and construction process. He is building a replica of the 1903 Wright *Flyer* that will compete for funds and attention against a number of other replicas expected to fly next year. But Hyde's machine has already been selected by the Experimental Aircraft Association to be the sole replica to fly at the Wright Memorial at Kitty Hawk, North Carolina, at 10:35 a.m. on December 17, 2003—precisely 100 years from the moment of the first powered flight.

More powerful offspring of the Wrights' engine hang on the noses of a Travel Air (left) and a Stearman that flew to the annual Wright Experience picnic.

Clear! Greg Cone fires up a Wright Vertical Four 1910 engine.

CAROLINE SHEEN (2)

In Hyde's workshop, guest Dick Roe lies on the lower wing of a *Flyer* simulator, left hand on stick, eyes fixed on a 30-inch monitor. Roe flew to the day's record altitude of 17 feet, banked on course, then warped the wings in an attempt at a circle.

Outside, Weldon C. Britton, who heads the Discovery of Flight Foundation as well as the northern Virginia chapter of the Virginia Aeronautical Historical Society, commands the card-table-turned-control-tower. Fly-in guests enter the pattern for the grass strip, and Britton toggles between the ground-to-air radio and a public address system. "The barbecue truck has just arrived," he announces.

VAHS program director Jim Davis intercepts VAHS-er Scott Crossfield before he can head for the barbecue. In November 1953, Crossfield, flying a D-558-II Skyrocket, made the first Mach 2 flight. Also on the field is Charlie Kulp of Catlett, Virginia. Kulp's foot-long white beard and plaid shirt mark him as the Flying Farmer airshow act. His Piper J-3 flies so slow it can backtrack in a strong breeze.

Davis pumps more hands. "This man here is Jane Garvey's personal pilot," he winks. Dave Clemmer flies the Federal Aviation Administration's Gulfstream IV, tail number N-1, as well as its Cessna Citation, N-4.

Picnicker Mel Scharman watches an overflying B-17. "I've flown some of those smaller bombers," he says, stabbing at beans and slaw. Scharman logged 3,700 hours in a B-36 Peacemaker before retiring to the Chesapeake Bay, where he now crabs from his pier. "I wouldn't fly in a single-engine plane. I wouldn't even pilot a single-engine boat," he says.

Announcer Britton summons guests to the back of the shop, where Greg Cone is coaxing into life the engine designed by the Wrights and built by their machinist, Charles E. Taylor. After an initial brief sputter, he adjusts the fuel-air mixture. Hyde heaves on a propeller, and the engine whirls to life and clacks for three minutes solid. The crowd applauds, then dissipates with the smoke: The fat lady has sung. Within 15 minutes, half the 268 souls have streamed out Glenn Curtiss Lane, and eight of the dozen fly-ins have taxied for takeoff. As each departs, it rocks its wings for the guests lining the runway and holding onto their summer hats as the winds pick up.

—Roger A. Mola

Back-Seat Astronomy

Normally Dan Durda flies airplanes with what he calls "little fans on the front." "I'm usually buzzing around in my Cessna 172 on the weekend," he says. So he found it surreal to be high over California's Mojave Desert one evening last spring, thinking, *My God, I'm in an F-18 with an astronaut at 49,000 feet.*

Is astronomy cool, or what?

Durda and Alan Stern, planetary scientists at the Southwest Research Institute in Boulder, Colorado, arranged the ride as a novel way to get their sensitive SWUIS-A (Southwest Universal Imaging System—Airborne) camera high enough above the obscuring atmosphere to search for a theorized belt of small asteroids in the innermost solar system. Durda and Stern believe there could be hundreds of these "vulcanoids" (named for the Roman god of fire and metallurgy), each several miles in diameter, circling between the sun and Mercury. But no one has yet discovered one, partly because they'd be so hard to see against the glare of the sun. The two scientists got permission—and NASA funds—to fly along with their camera last spring as back-seaters in an F/A-18B that NASA uses for proficiency training. As far as they know, they're the first people to do astronomy from a fighter jet.

Scientists have long used larger aircraft like the KC-135 as flying observatories, but the F/A-18 is 10 times cheaper to operate. It's nimble enough to do precision pointing, and the SWUIS-A camera—along with its mounting equipment and electronics—is small enough to fit in the tight cockpit, with the scientist alongside to tweak it. NASA pilots have to fly a number of night (or in this case twilight) proficiency flights, and the two missions seemed a good match.

Durda and Stern made their first F/A-18 flights two years ago, with a different quarry in mind. They flew to a precise spot off the California coast where they could watch a star being eclipsed by a tiny asteroid called 308 Polyxo; the eclipse helped them determine the asteroid's size and shape. For a fighter aircraft, it was "kind of a milk run of a flight," says Durda—no high-G maneuvers. Still, it was "a little bit of a technical challenge" to arrive at the right place, at exactly the right time, with the proper orientation to catch Polyxo on camera.

Last summer Durda was still examining the images from the previous spring's vulcanoids search, with nothing to report so far. It's likely the scientists will have to fly even higher to get the dark sky they need, and they are trying to wangle a ride on an Air Force U-2 this fall, which could take them to 73,000 feet.

This kind of astronomical observing is not for everyone, Durda says. He and Stern, also a pilot, underwent training to learn, for example, how to eject. Durda studied the F/A-18 manuals, aware that he'd quickly become more than a passenger if the pilot were disabled. "I probably could have gotten it down to the ground, maybe even to a very sloppy landing on a runway," he says. His observing run, piloted by former shuttle astronaut Rick Searfoss, went just fine.

—Tony Reichhardt

HEADS UP

Sidewinder 50

50th Anniversary of the Sidewinder Missile
Nov. 1–3
U.S. Navy Museum of Armament and Technology, Naval Air Warfare Center, Weapons Division, Naval Air Weapons Station, China Lake, CA 93555
(760) 939-2002
www.chinalakemuseum.org

In 1952, the Navy's Bureau of Ordnance granted the Sidewinder heat-seeking air-to-air missile, conceived by William Burdette McLean, official program status. The Sidewinder is the most widely used air-to-air missile in the West; today's AIM-9 is one of the oldest, cheapest, and most successful missiles in the U.S. weapons inventory. Tha Naval Air Warfare Center will host a three-day celebration including historical weapons exhibits, museum and laboratory tours, an evening gala, presentations, and a golf tournament. If you've fired a Sidewinder—in combat, in the lab, or on the range—join the Nest of Vipers: A Supremely Selective Society of Snake Shooters, which will be established at the celebration.

Can You Spot the Fake?

Early this summer, Boeing introduced its X-45B Unmanned Combat Air Vehicle by rolling out a full-scale mockup developed by Pacific Miniatures and TransFX. (PacMin makes sophisticated desktop models used by the aerospace industry to promote sales; TFX is a prototyping facility in Southern California famous in entertainment circles for the hot cars it has made for *Batman* movies.)

A few weeks later, Boeing held a press conference to celebrate two flights by its X-45A, a technology demonstrator called the first unmanned system designed from inception for combat. Lessons learned from both aircraft will influence the A-45, which is slated to go operational in 2008.

Which aircraft was airworthy?

THE AIRWORTHY X-45A IS THE ONE WITH MARKINGS.

CHAD SLATTERY/AEROPIX.COM (2)

Yellow Fever

Traditionally, Piper Cubs are yellow. Some early and late models were painted differently, but yellow is what we've come to expect—yellow with a black flash along the fuselage, and two black cylinder heads projecting on either side of the nose. Thus accoutered, a Piper Cub is one of the most recognizable

aircraft in the world. Seeing a few hundred tied down beside the grass runway at Lock Haven, Pennsylvania, where most Cubs were built, and with others taking off and landing all day long, one gets the impression of a convention of motorized canaries.

The event that brings the Cubs to this town, on the west branch of the Susquehanna River, is the Sentimental Journey, an annual gathering that Lock Haven hosts for anyone durable enough to fly an underpowered airplane through the wooded mountains and misty valleys of mid-Pennsylvania. Not every arrival is a Cub, but most date to aviation's first half-century.

William Piper was 22 when the Wright brothers made their first powered flight; he died not long after Neil Armstrong walked on the moon. In the meantime, as Henry Ford did with the Model A and Ferdinand Porsche with the VW Beetle, Piper built the perfect vehicle for its era, which in the case of the classic J-3 lasted from 1938 to 1947. Today the company is reorganized, as New Piper Aircraft, and located in Florida, where it builds small numbers of fairly complex private aircraft.

An original Piper J-3 can carry enough fuel for a bit more than two hours in the air, allowing for the Federal Aviation Administration's required reserve. Len Buckle, a 71-year-old from San Diego, installed extra fuel tanks in the wings of his J-3 before he made his first Sentimental Journey in 1986, and he sets out for Lock Haven with a week to spare. "They act like it's a big deal coming 2,500 miles," Buckle says, "but I just think of it as 25 individual 100-mile trips."

Three Californians have flown to Lock Haven this year, along with half a dozen Canadians, but most of the aircraft fly in from the eastern United States. Among them are two J-2 models built in 1936. One is based in western Pennsylvania and belongs to Robert Stewart, 82, who bought it in 1939 but soon traded up to a more powerful model. Years later, he located the airplane, bought it again, and restored it with the aid of his sons and a granddaughter. The young woman, April Stewart, made her first solo flight in the J-2 at the Sentimental Journey in 1998. It was supposed to be a secret triumph, completed while everyone else was busy with the nightly corn bake, but word got out, and hundreds lined the grass runway to cheer April's flight of passage.

About the same time, her dad decided to restore a J-2 of his own. Mark Stewart is 48 and lives in Ohio; April is now 20 and a junior at Carnegie-Mellon University in Pittsburgh, so progress depended on how often the family could get together. They're just completing the project as I happen by: three generations of Stewarts, stenciling "NC16621" on the rudder. (All U.S. civilian aircraft have tail numbers beginning with "N"; the "C" is archaic but can be used if the airplane once bore it. A tail number generally remains unchanged for the life of an airplane, which is how the eldest Stewart managed to locate his Cub, NC16667, a generation after selling it.)

The design's final iteration was the PA-18 Super Cub, manufactured off and on until 1994. The tube-and-fabric trainer boasts 150 horsepower, an electric starter, and radios, and it sold for about $80,000. Home builders and small manufacturers are still turning out variations on the design today, for upwards of $140,000. (The newspaper *Trade-A-Plane* has ads for vintage J-3s selling for $20,000 to $35,000.)

DAN FORD

Old Yellers are up to old tricks at the Sentimental Journey Cub fly-in.

HEADS UP

LANI MUCHE

Experimental Aircraft: Northrop N9M-B

Saturday, November 2, 10 a.m.
Planes of Fame Air Museum
Cal-Aero Field
Chino Airport
Chino, CA 91710
(909) 597-3722

Experimental aircraft are the subject of November's monthly special event at the Planes of Fame museum. The event opens with a seminar featuring experimental test pilots and concludes with a flight demonstration of the museum's Northrop N9M-B flying wing.

The flying wing design was pursued by Jack Northrop in the 1930s and '40s. The only flying example is the N9M-B, one of four aircraft built as one-third-scale development aircraft for the B-35 and B-49 bombers. The basic concept was eventually validated in the Northrop B-2A stealth bomber.

At each of the museum's events, a drawing is held for the grand prize: a back-seat flight in a World War II aircraft.

HEADS UP

High School Students, Prepare to Scramble!

Enter the Team America Rocketry Challenge: Design, build, and launch a model rocket that will carry two raw eggs to 1,500 feet and return them intact by parachute to compete for a prize pool of $59,000. The Challenge is sponsored by the Aerospace Industries Association and the National Association of Rocketry to encourage students to choose a career in aerospace. The application deadline for the April 12-13 northern Virginia event is November 15. Visit *www.rocketcontest.org, www.aia-aerospace.org,* or call the AIA at (202) 371-8428.

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The Cub's popularity can be measured by the attendance at the Sentimental Journey: more than 4,000 visitors by the time I leave the parking lot on Friday afternoon.

—Daniel Ford

Rockdonnell Rocks On

During a weekend last July, some 100 high school students participated in the Ninth Annual International Space Settlement Design Competition at Kennedy Space Center in Florida. The contest was organized by Anita Gale and Richard Edwards with financial support from the American Institute of Aeronautics and Astronautics. Competitors sought to win a contract to build a large colony on Mars. Students were assigned to four competing aerospace firms: Dougeldyne AstroSystems, Vulture Aviation, Rockdonnell, and Grumbo Aerospace. Each company had an adult engineer as a CEO, with students as the president and the heads of departments.

In 44 hours of virtually nonstop work, each corporation was to respond to a detailed Request for Proposal by preparing a 50-page document describing its concept for a colony design. A brochure warned: "You will have too much data in some areas, too little in others, not enough time, personnel conflicts, technical conflicts, difficulty in describing your entire design, and questions from the judges that you consider unfair." In other words, the competition imitated as realistically as possible an aerospace firm's actual experience in preparing a proposal.

The competition was set in the year 2051 and included in its scenario lengthy company histories and highly developed space infrastructures. Grumbo, for instance, had built the Grumbo Jumbo, a large, low-cost launch vehicle. Space colonies were operating in high Earth orbit, on the surface of the moon, and on the Martian satellite Phobos. These colonies provided homes for subcontractors, which had such names as Lossless Airlocks and Tanks-a-Million. Other firms built controlled-fusion units both for energy and for propulsion, with the Magnetic Propulsion Company supplying mass drivers. The students were to draw on the subcontractors' products and services in preparing their proposals.

The kids wore company T-shirts: red for Grumbo, dark gray for Vulture, white for Rockdonnell. All had participated in a qualifying competition that had designed the Phobos settlement. Many had taken part in previous contests as well. Rockdonnell president Yvonne Chan, a veteran at 15, said, "The main thing I remember is going without sleep."

A number of students brought laptops, which supplemented desktop computers. Fragments of overheard conversation revealed the companies' design decisions: "We'll use maglev for transportation. It's faster than a railroad, and it avoids problems with Mars dust." "Stick with hydroponics. It's been proven." "We gotta have bees. We need them to pollinate the flowers. That's how we get fruits."

On Sunday, the Grumbos were in a darkened room looking at viewgraphs as one group presented its work to the entire company. At Rockdonnell, rock music filled the room. "I hacked into the audio system," a student explained.

The work continued through Sunday, with Monday morning set aside for company officials to make their presentations. The conference room had only a single screen for showing viewgraphs, but Gale had bought a bedsheet at Wal-Mart to serve as a second screen. After lunch, director Dick Edwards announced that the contract had been awarded to Rockdonnell.

Whoops and hollers greeted the announcement. The same company had won the previous year's competition as well, and someone yelled, "Next year we'll go for a three-peat!" Someone congratulated Yvonne Chan: "It was the management." "No," she replied modestly, "it was the team."

—T.A. Heppenheimer

UPDATE

The Next X

The latest batch of designated X-planes ("The NeXt Generation," Dec. 1999/Jan. 2000) include:

- X-45 Boeing Unmanned Combat Air Vehicle (see "Can You Spot the Fake?" box, p. 11).
- X-47A Northrop Grumman carrier-based UCAV-N (unmanned combat air vehicle—navy) and a larger follow-on, the X-47B.
- X-48A NASA Blended Wing Body. The subscale demonstrator BWB is a flying wing that may evolve into a more fuel-efficient airliner, which could carry more passengers than today's tube-and-wing design.
- X-50A Boeing Canard Rotor/Wing. The CRW strives to combine the vertical-takeoff-and-landing capability of a helicopter with the high speed and agility of a fixed-wing jet aircraft.

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Sailors' Delight

In September 1911, Orville Wright delivered a crated Wright model B-1 to an armory in Annapolis, Maryland. Lieutenant John Rodgers, only the second aviator to have flown for the U.S. Navy, assembled the biplane in the course of an afternoon with the help of a few midshipmen. The next morning, Rodgers rose from Farragut Field in the tiny craft. The armory is now the U.S. Naval Academy's Dahlgren Hall, and the historic space is home to a student union, restaurant, ice hockey rink, and, until last summer, a 1941 N3N-3 floatplane.

On June 11, 2002, a team from the Collections Processing Unit of the National Air and Space Museum set up operations in Dahlgren to retrieve the Navy trainer, which had been on loan to the Naval Academy for 23 years. The aircraft had been hanging from the building's rafters by its hoist sling, and with the rink drained for summer, senior Museum specialist Ed Marshall, team leader Lars McLamore, and team members Jeff Mercer, Doug Dammann, Scott Neel, and Samantha Gallagher took the opportunity to bring the N3N-3 down and transport it to the Paul E. Garber Preservation, Restoration and Storage Facility in Suitland, Maryland, where it will be buffed and shined for display at the Steven F. Udvar-Hazy Center, which is scheduled to open at Washington-Dulles International Airport in northern Virginia late next year.

It took three days to rig, lower, disassemble, and secure the aircraft on the trailer for the ride to Garber. "We really rock and rolled," says McLamore. "We've got 300 more airplanes to move." Samantha Gallagher, who earned her commercial driver's license early this year, got her first taste of transporting an artifact. "The U.S. Naval Academy streets are not made for tractor-trailers," she says, "but there were plenty of eyes watching out for me."

The Naval Aircraft Factory in Philadelphia began manufacturing land and floatplane versions of N3N-3s in 1938, turning out more than 800 of the trainers. The N3N was nicknamed "Yellow Peril"; depending on whom you ask, the nickname refers to its tricky ground-handling characteristics or the challenge it presented to student pilots, who couldn't advance until mastering the yellow-painted trainer. N3Ns were used in primary Navy flight schools throughout World War II. Afterward, some 200 were sold as surplus; the 235-horsepower Wright R-760-8 Whirlwind 7 radial was powerfully suited for cropdusting. The Museum's N3N-3, number 3022, was among a group transferred in 1946 from Cherry Point, North Carolina, to a seaplane base at Annapolis. Four years later, Annapolis was designated a Naval Air Facility, and cadets continued to train in N3Ns over the Severn River. In 1961, Yellow Perils, the last biplanes in U.S. military service, were retired, and number 3022 became part of the Museum's collection.

In 1979, the airplane returned to Annapolis. Dolphin Overton, a Korean war pilot and antique airplane collector, underwrote the aircraft's restoration at the National Air and Space Museum and requested that it be loaned to the Naval Academy to honor the occasion of a friend's retirement. The friend was Overton's cousin, Admiral James Holloway III, a naval aviator and Academy graduate who retired as Chief of Naval Operations in 1978.

Though 3022 never saw combat, it occasionally found itself in the line of fire once it got to Dahlgren Hall. Hanging 20 feet above one of the hockey rink's goalposts, it blocked a few shots. McLamore points to chips, crinkles, and scuffs on 3022's fabric skin. Garber staff were able to erase most of the puck

Five-Minute Fantasy Flights

Visitors to the National Air and Space Museum's "At the Controls—Flight Simulator Zone" can fly a fully aerobatic flight simulator. During the five-minute experience in the MaxFlight FS2000, operators can emulate the open-cockpit barnstormers of the past or the military fighter pilots of today. The simulators, which are equipped with a sound system and a 58-inch virtual reality screen, can pitch and roll after rising 12 feet off the ground. After strapping themselves in to the two-seat "cockpits," visitors can move the joystick and fly through loops, 360-degree barrel rolls, and other aerobatic maneuvers. Many of the MaxFlight simulation programs are based on aircraft that belong to the Museum, such as a North American P-51C Mustang, a Mitsubishi Zero, and the *Spirit of St. Louis.*

ERIC LONG

To ride in the simulators, visitors must be at least 48 inches tall; children who stand 42 to 47 inches must be in the company of an adult.

DON LEONARD

COURTESY USNA ARCHIVES

A yellow N3N-3 trainer was an eye-catcher at the U.S. Naval Academy for 23 years (top). In 1957 midshipmen launched an N3N from the Severn River in Annapolis.

scuffs with Simple Green, a degreaser.

The Yellow Peril also must have proved an irresistible target for spectators sitting in the rink's balcony seats. When the collections processing team looked inside, they found hundreds of little triangular paper "footballs," the kind high school kids—or midshipmen at hockey games—flick through imaginary goal posts.

For now, the N3N-3 sits partially disassembled in Garber's Building 20, awaiting next summer's 38-mile haul to the Hazy Center. "It's a floatplane, not an amphib or plane with landing gear, so it's not meant to sit on its float forever," says Tom Alison, chief of the Museum's collections division. After assembly and a good scrubbing, the hanging point on the aircraft's hoist sling will be reinforced, and the Yellow Peril will hang from the rafters of the aircraft display hangar near Dulles for years to come.

—Roger A. Mola

MUSEUM CALENDAR

October 5 & November 9 Evening Stargazing. Join National Air and Space Museum astronomer Sean O'Brien for an evening that will begin with a short night sky orientation followed by guided viewing of various astronomical objects through a telescope. Dusk to 11 p.m. at Sky Meadows State Park in Virginia. There is a $4 park entrance fee per vehicle. For further information, call (540) 592-3556.

October 10 G.E. Aviation Lecture: "An Evening with Chuck Yeager." Brigadier General Charles E. Yeager will share memories of his transformation from an enlisted man in the U.S. Army Air Corps to a Bell X-1 test pilot. Free tickets may be obtained at the Museum's Langley IMAX Theater box office, through *www.tickets.com*, or by calling (800) 529-2440. Lockheed IMAX Theater, 7:30 p.m.

October 26 Monthly Star Lecture: "JPL—40 Years of Planetary Exploration." Join Woody Davis of the Jet Propulsion Laboratory as he discusses Mariner 2, the first successful exploratory probe of Venus. Public telescopic observing follows the lecture, weather and time of sunset permitting. Einstein Planetarium, 6 p.m.

November 16 Astronomy Fair. Join local experts at the National Air and Space Museum to learn how to select, use, and care for astronomy instruments. Telescopes, accessories, and educational materials will be displayed for visitors to enjoy. 10 a.m. to 4 p.m.

November 24 "A Star Shines on the Hour of Our Meeting." Join National Air and Space Museum astronomer Sean O'Brien as he uses the planetarium to explore the celestial mythology of J.R.R. Tolkien's *The Lord of the Rings*. Passages and poetry will be read. Public telescopic observing follows, weather and time of sunset permitting. Einstein Planetarium, 6 p.m.

Except where noted, no tickets or reservations are required. To find out more, visit www.nasm.edu *or call the Smithsonian Information line at (202) 357-2700; TTY (202) 357-1729.*

Ration of Luck

There's probably nothing to it, but sometimes I think that airplanes, and people as well, come equipped with a finite amount of luck. As with all things finite, maybe luck can be used up. And when it's gone, it's gone.

In the spring of 1961, I was one of eight or so U.S. Forest Service smokejumpers at the Royal Thai Air Force base in Takhli, on loan to the Central Intelligence Agency. We were theoretically not aware of the identity of our employer because our job came with a "risk of capture," and the less we knew, the better. The CIA liked to use smokejumpers for airdropping supplies because we were very good with parachutes, did not get airsick, were strong and fit, and were used to operating without much supervision. Perhaps most important, at least in the eyes of bureaucrats, we were not military, and any U.S. government connection to us could be denied should we end up in unfriendly hands. Our duties were to rig, load, and drop arms, ammo, and food to a small but growing irregular army in Laos.

malaria pill. An individual PDO would rig cargo and load airplanes one day and fly and drop the next. Flight days were the best because it was a lot cooler at 12,000 feet and you could catch up on sleep for much of the time aloft. You also got extra pay—"danger money"—for time spent north of the Mekong River. The down side was that bad things sometimes happened north of the Mekong River.

The airplanes were Curtiss C-46 Commandos. After flying the China-Burma-India "Hump" in World War II, they were bought by Flying Tiger general Claire Chennault when he started his Chinese airline, Civil Air Transport (CAT). Controlling interest in CAT had been bought by the CIA, and CAT had recently spun off a corporation called Air America, which could legally bid on U.S. government contracts. A different CAT/Air America C-46 and crew would rotate into Takhli every week. One week, a crew came in C-46, tail number B-916—a particularly good airplane and crew.

"Rich" Richardson was the pilot, an ex-Flying Tiger and fun to work with. First Officer Fred Reilly was an ex-U.S. naval aviator and deeply Irish. On this particular day, the PDOs were Fred Barnowsky, two trainees from the Thai army, and me. We got to our drop zone early in the morning and saw the safety signal, which for this drop zone was a white "0."

The CIA liked to use smokejumpers because we were very good with parachutes, did not get airsick, and were used to operating without much supervision.

In this incarnation, our job title was Parachute Dispatch Officers—PDOs.

We lived in (and were confined to) a not-too-large compound with a not-too-bad barracks. The food was okay, although for some reason the eggs in the mess hall tasted of diesel fuel. There was a movie every night, which tended to be the same movie every night, so everyone memorized the dialogue and shouted it at the screen, which was the back wall of the mess hall. There was beer, and there were bug fights: Collect a variety of beetles, mantises, and other six-legged items in a big dishpan, stir it with a stick until all occupants were highly annoyed, and then bet on the bug you like. The workday began in the pre-dawn dark and ended well after dark. The work weeks were seven days long; Sunday was different only because that was when you took the

The people on the ground were supposed to display this signal only when they heard the airplane overhead, but this bunch of good guys had gotten lazy and made their signal permanent. The previous night, the good guys had been chased off by the bad guys—Pathet Lao, or North Vietnamese, or both. The place was overrun with hostiles, the signal on the ground said it was safe to make the drop, and here we came.

While we looked the drop zone over, we heard a four-round ripple of machine gun fire. Barnowsky and I looked at one another, then shrugged. Probably some training going on down there, we thought. Later, we would learn that if you are in an airplane and you hear gunfire, what you are hearing is not the weapon firing but the sonic boom of flying bullets, many of them, coming right at you.

On the next circuit, when we were lined up to drop, the world turned into a popcorn popper. Bullets everywhere. They just ate us up. I was nearest the cockpit and so went forward, bent over, and told Rich that they were shooting at us. He said he knew already. There was a particularly loud crack that made my ears ring for some time afterward. We found later that while I was bending over, a bullet had passed behind my head. Old Marine Corps instincts said that I should hit the deck, but then logic whispered that this would be dumb because those guys were below us shooting upward, and flat on the deck would offer the largest possible target. For a moment it seemed like the smart thing to do might be to climb on top of a pallet of ammo. This began to seem dumb also, and in the end I just stood there and listened to the popcorn popper until we flew out of it.

Barnowsky and I checked the damage and counted bullet holes. Fuel was pouring out of the left wing, but Rich said no problem, we had an empty tank on the right we could use. He started transferring fuel, and then gas started pouring out of the right wing too, through a hole we hadn't known about.

C-46s were famous for enduring an engine fire for about 45 seconds before the wing came off. B-916 now had fuel pouring out of each wing, over each engine exhaust. Everybody chuted up and kept their eyes on the streams of avgas. On approach to the airport in the Laos capital of Vientiane, as soon as we were too low to jump, we shucked off the parachutes and pulled open anything that resembled an emergency exit. We waited to see what would happen when B-916 backfired on final approach, as it always did, and to see if one or both of the main

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tires had caught bullets and gone flat.

Neither main was flat, and B-916 did not backfire. We just rolled on out to the parking ramp and shut down the engines. It was rainy season, and the ramp was submerged in several inches of water. We piled out and watched fuel pouring out, spreading avgas rainbows all over. We waded about a hundred yards before we found a dry spot where we could safely light smokes. We all stood there, shaking and cussing and puffing away.

About a year later, Fred Reilly was landing with a load of rice on the Plaines des Jarres, a field of ancient monuments in north-central Laos, just as the Lao Neutralists split in two and started an intramural firefight. Reilly was stitched across the legs by .50-caliber machine gun fire and his C-123 piled up at the end of the grass runway, crushing him under several tons of rice. The wreckage of his airplane, shining on the grassy plains, became a landmark.

COURTESY DONALD V. COURTNEY (2)

The author surveys the forbidding Laotian terrain from a C-46; right, a successful drop at an airstrip carved on a mountaintop.

B-916 went back to Tainan and was rebuilt. Right after it came back, it was hit just south of the Plaines des Jarres, got a fire in the left engine, and shed the left wing in less than a minute. Two Thai PDOs—Varaphong and Kukinchin—and nobody else got out on static-line chutes at about 200 feet. Very soon after, Kukinchin was killed when C-46, tail number 77 Victor, went straight into a ridge and blew up.

Meanwhile, back at Takhli, another C-46, B-136, came in with pilot Bill Beale. Beale had a Smilin' Jack moustache, a laid-back outlook, a fat and interesting logbook, and an addiction to paperback westerns.

On a hot, humid morning, B-136, with Beale, a first officer whose name I don't remember, a big load of ammo, and PDOs Art Jukkala, Russ Kapitz, and two Thai army trainees, left Takhli and headed north. Once the load was ready for delivery, the guys in the back sacked out. Onboard, even when you are in a deep sleep, one sound will bring you right out of it: a change in engine power settings. Jukkala got up and went forward, looked over Beale's shoulder, and saw a ridge coming—a ridge that the airplane would not clear, and there were spur ridges on both sides that prevented a turn out of trouble. B-136 was in a box.

Jukkala woke up everybody and had them strap in. Then he belted himself in, listened to the power go up as far as it would go, and waited for the crash. It didn't come, and finally he got up and went forward again. Over Beale's shoulder he saw B-136 just barely scrape over that first ridge—and come face to face with another one that was higher still. By now, there was nothing to do but stand there and watch.

B-136 buried its nose in a big tree. Branches went by on both sides of the cockpit; there was a series of thumps. The airplane stalled and nosed over.

Laos is limestone country—sheer white karst cliffs all over. B-136's tree was on the edge of one of those cliffs, and when the airplane nosed over, it fell free, over the edge and down. It picked up flying speed. Beale nursed the nose up and flew away.

Air blasted up through the cockpit, blowing dirt and dust up pant legs and into faces. The crew went to Vientiane, dropped the cargo over the airport, and headed south to Udorn, Thailand. Beale put B-136 onto the pierced-steel-planking runway, and everybody on board was soon kissing muddy ground. Another C-46 came up from Bangkok, collected some of us at Takhli, and that night flew north to pick up Beale and company and get the roller conveyor and other drop equipment off B-136 so we could use it the next day. We went over B-136 with flashlights, whistling and making blasphemous comments in awed tones.

> On the next circuit over the drop zone, the world turned into a popcorn popper. Bullets everywhere. They just ate us up. There was a particularly loud crack that made my ears ring for some time afterward. We found later that while I was bending over, a bullet had passed behind my head.

On the left side, a branch a foot in diameter had passed between the fuselage and the propeller arc, missing the prop but driving a hole two feet deep in the wing root. Another branch punched a head-size hole right under Beale's feet, missing the rudder pedals but letting in the torrent of air that sent all that World War II dirt up Beale's pant legs. All along the belly were dents and holes. The left ends of the horizontal stabilizer and elevator were sheared off about an inch from the outboard hinge. Everywhere there was damage that just barely missed being fatal.

Like B-916, B-136 went to Tainan for a total rebuild, and was back in a few months. That summer, while trying to turn out of a mountaintop karst bowl, heading for the one gap where it could get out, B-136 hooked a wing into a spur ridge and cartwheeled into little pieces, its luck all used up. On board were smokejumpers Dave Bevan, John "Tex" Lewis, and Darrel "Yogi" Eubanks. Their deaths pretty much brought an end to the CIA PDO program, and Air America began hiring its own cargo droppers. By the end of 1961, most of the CIA PDOs had moved on to other things. On a hot day in 1962, Bill Beale hit another tree at the end of a short airstrip. It was his final tree.

—Donald V. Courtney

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Sikorsky's Piano Man

SIKORSKY ARCHIVES

Sergei Rachmaninoff (center) was instrumental in getting the Sikorsky S-29A airliner off the ground. Igor Sikorsky (left) had labored with Baron Nicholas Solovioff (right) and a dwindling workforce to launch the 14-passenger transport.

In the fall of 1923, Russian aviation pioneer and designer Igor Sikorsky was facing economic disaster. His newly established Long Island company, Sikorsky Aero Engineering Corporation, had nearly run through its meager resources.

Sikorsky, who was virtually unknown in the United States, was working on the S-29A ("A" for America), a twin-engine, closed-cabin, 14-passenger transport. His "factory" was set up on a chicken farm owned by his friend Victor Utgoff, a former lieutenant in the Russian navy. Aside from the money problem, the work had to be done by hand, since the farm did not have appropriate machinery. Sikorsky and his workers, mostly Russian immigrants, were raiding junkyards for parts for the airplane, which had to be constantly redesigned depending on the equipment and materials they found. The main structure of the fuselage was built with angle irons from discarded bedsteads. Turnbuckles, which were used to adjust wire tension, were found in a Woolworth's five-and-dime. The landing gear was installed with the help of Sikorsky's nephew, Dmitry (Jimmy) Viner, whose responsibilities included ditch digging. "Since there was no jack to raise the fuselage," Frank Delear wrote in *Igor Sikorsky: His Three Careers in Aviation*, "Jimmy dug under it to make space for the wheels and landing struts. With the gear installed, the plane was then pulled out of the ditch."

Since the work was done outside, cold weather brought it to a standstill. The enthusiasm of Sikorsky's men, who had worked for weeks without pay, was at its lowest, and the workforce dropped to a mere handful. The few dollars that could be raised by selling stock in the company were spent mostly on food.

One Sunday, a chauffeur-driven limousine drove up to the chicken house. A tall, slender figure in a long black coat stepped out of the car and walked up to the airplane. In total silence, he inspected the aircraft.

"Everyone on the farm got greatly excited," says Sergei Sikorsky, Igor's son and the retired vice president of Sikorsky Aircraft, who remembers well how his father described the event. "They all immediately recognized Sergei Rachmaninoff as their guest. My father went up to him and they began to talk. After about a half-hour visit, Rachmaninoff said, 'I believe in you and your plane and I want to help you.' " The composer wrote a check for $5,000 (approximately $100,000 today). With a smile, he gave the check to the stunned Sikorsky and said, "Pay me back whenever you can."

According to Sergei Sikorsky, Rachmaninoff was not just investing money. He was making a friendly gesture of help to one of the brightest of his countrymen, the first to build multi-engine aircraft, including the biggest aircraft at the time, the four-engine *Il'ya Muromets*. Somehow Rachmaninoff had come to find out that Sikorsky was pursuing his visionary path in defiance of many hardships.

Thanks to Rachmaninoff's support, the company managed to rent an old wooden hangar at a corner of Roosevelt Field, where the workers moved the airplane with the help of the local police, who had come to respect the hardworking Russians. A few days later, Igor Sikorsky and his family moved into a rented house in Westbury.

As a token of appreciation, Sikorsky asked Rachmaninoff to be the company's first vice president. The composer accepted, adding much to the company's prestige. Thus was Sikorsky's career in America launched, and thus began a close friendship. "My father felt very proud," says Sergei Sikorsky, "when in 1929 he sent Rachmaninoff a check for $5,000 plus interest."

Rachmaninoff made many visits to Sikorsky's house, and the Sikorsky family attended Rachmaninoff's concerts at Carnegie Hall in New York City. Sergei Sikorsky recalls that Rachmaninoff once brought fellow pianist and composer Josef Hofmann to see Sikorsky building airplanes at his Stratford, Connecticut plant. "I remember my mother had to prepare an impromptu lunch for them," recalls Sergei Sikorsky. "I also remember that there were two or three reporters that were following Rachmaninoff to the factory and then to our home, and I remember my father had to walk out to the front door and ask the press, 'Gentlemen, please don't walk in our front yard or back yard. Please don't try to peek through the windows and photograph, because it is very impolite. We are here just with friends.' "

On September 25, 1924, after one more year of tribulations, including a crash, the S-29A took off successfully, and with it the Sikorsky company. Many demonstrations and charter flights followed, but the company made its first real profit—$500—by using the airliner to transport, appropriately, two grand pianos from New York City to Washington, D.C.

—Vadim Prokhorov

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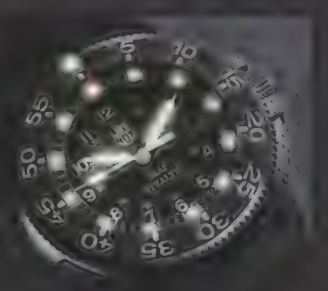

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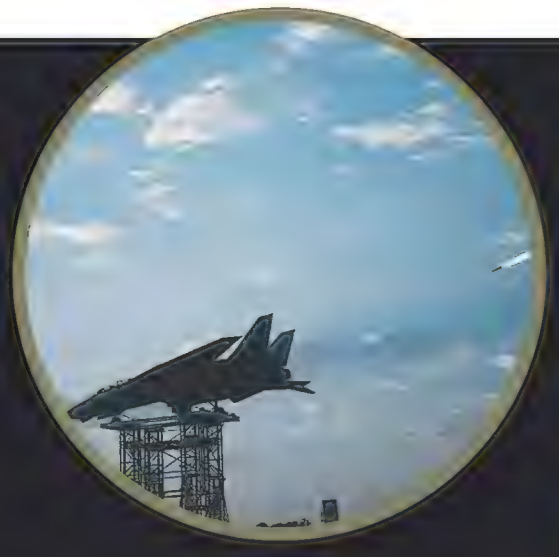


SHOOT

BY CARL HOFFMAN
PHOTOGRAPHS BY CHAD SLATTERY

Sometimes you have to destroy the aircraft in order to save it.

SOMEDAY, ON A MISSION to extract a special operations team, a pilot will fly into enemy territory in an MH-60S, a forthcoming U.S. Navy version of the Sikorsky Black Hawk helicopter, and an anti-aircraft round will drill into the MH-60's rotor drive system. For the shooter on the ground, hitting the helicopter won't be easy—it will be moving fast, the rotors and shaft spinning faster—but there are always lucky shots. The pilot will feel a jolt and wonder if his aircraft can survive the strike.

Joe Manchor is about to find out, long before the pilot has to. Dressed in sneakers and blue jeans, the lead engineer on the live-fire test and evaluation of the MH-60S has a prototype of the helicopter locked onto a steel platform, dead in the sight of a nasty-looking gun. We're at the Naval Air Warfare Center's Weapons Survivability Laboratory at China Lake, California. The rig is 10 miles into China Lake's hidden city, 3,800 square miles—an area the size of Delaware—of high Mojave scrub and mountains. Outside the sky is deep blue, the winter sun glaring, but we're hunkering in a windowless control room protected by a 20-foot-tall wall of steel plate. Two hundred yards away on a test pad stands the heli-

'EM UP

Ouch! A retired F-14 takes a Stinger missile in the aft fuselage during a 1999 test at the Navy's Weapons Survivability Laboratory in China Lake, California. (The incoming missile is visible at the right of the first frame.) With such violent business to conduct, the lab is located in unpopulated desert (left).

OPPOSITE INSET PHOTOS: U.S. NAVY (3)

copter, prepped for its final judgment. Though it was built with care and is worth over $10 million (and no doubt coveted by dozens of aviation museum curators), it is being sacrificed for the future glory of the MH-60s that will go to war.

The helicopter is bolted to a system of steel beams and remotely controlled airbags and actuators that took eight months to design and build. Mounted on another steel frame 30 feet from the MH-60 and level with its rotor mast stands the remotely operated, electronically fired gun. Exactly what bullet it's about to shoot is classified, but the gun is capable of firing a 7.62-, 12.7-, 14.5-, 23-, or 30-mm anti-aircraft round. If the test works as planned, the gun will fire 0.0012 second before the helicopter's pitch control link spins into its sights, enabling the projectile, traveling at 2,510 feet per second, to smash into its laser-painted bull's-eye. High-speed video cameras will record the shot, allowing Manchor and his team to analyze what happens as the bullet finds its mark.

Such sacrifices are routine at China Lake, where combat aircraft both old and new are methodically destroyed by guys like Manchor. The tests have changed the way airplanes and helicopters are designed and have enabled pilots to get safely home in aircraft riddled with holes. "We lost 5,500 helicopters and airplanes in Vietnam," says Robert E. Ball, Distinguished Professor, Emeritus, at the Naval Postgraduate School in Monterey, California, "and in Desert Storm, four [F/A-18] Hornets got hit by infrared [-guided] surface-to-air missiles and all came back." Ball's textbook on aircraft survivability is the discipline's bible.

As effective as live-fire survivability testing seems, however, it is controversial. Contractors and program managers chafe over the time-consuming and destructive testing, which will reveal flaws in expensive hardware only after its development is well under way—sometimes at the stage of full-scale production. Today's single shot at the MH-60's pitch control link—a slender rod that adjusts the pitch of the rotor blades—has taken several days to set up. The complete MH-60 live-fire test sequence will take three years. Should serious vulnerabilities be uncovered, key components will have to be redesigned.

Survivability, according to WSL director Jay Kovar, is determined by the answers to a series of three questions: "Can he see me? If he can see me, can he hit me? If he can hit me, can he kill me?" The operation run by Kovar, a strapping former nationally ranked discus thrower, focuses on the last question in the series.

In the opening days of World War II, airplanes were easy to see, hit, and kill. On May 14, 1940, the British lost 23 of 64 Blenhiem and Fairey Battle bombers. And when Germans invaded the Soviet Union a year later, more than 1,400 Soviet airplanes were lost in a single day. As the war ground on, air forces tried to decrease the visibility of aircraft or increase their defenses. "Think about it," says Robert Ball. "Eight of the 10 men in a B-17 were manning machine guns, and the weight of the guns and ammunition was about twice the weight of the bombs carried."

By the time of the Vietnam War 20 years later, little had changed. "There was very little attention paid during the design of any aircraft of that era to the damage that enemy guns or guided missiles might do," says Ball. Increasingly sophisticated high-altitude surface-to-air missiles forced pilots to fly low, which made them vulnerable to small arms fire.

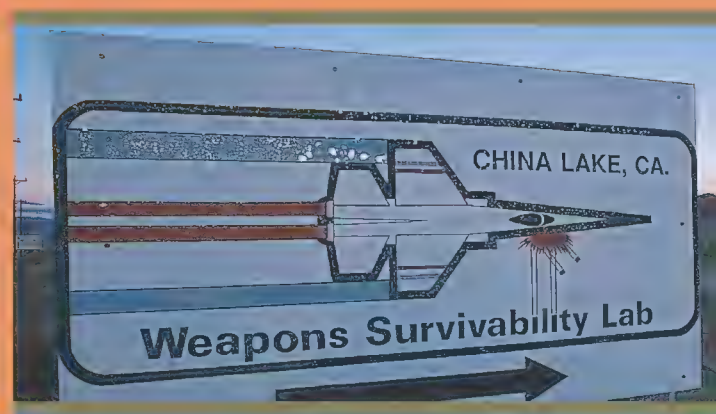
"All of the planes flying in Vietnam were designed for a completely different environment," says Chuck Myers, the former director of air warfare in the Office of the Secretary of Defense. "The F-4's mission was to intercept incoming bombers and hit them with Sparrow missiles. The F-105 was designed as a low-altitude nuclear-strike airplane to drop bombs and leave. You didn't worry about bullets. But those planes were terribly vulnerable. We sent them into the conventional [warfare] morass of Vietnam, and when those SOBs got hit with bullets they came apart." Ditto with helicopters, which were used in combat in large numbers for the first time in Vietnam. By 1970 some 1,500 had been shot down; their fast-spinning turboshaft engines and light materials proved highly vulnerable to 23-mm anti-aircraft fire.

With losses so high, the Air Force Systems Command dispatched a fact-finding team to Vietnam in 1966 to determine the cause. The directive setting up the mission included the conjecture that aircraft were crashing from catastrophic structural damage. But Dale Atkinson, then an aerospace engineer at the Air Force's flight dynamics laboratory, thought otherwise. After examining damaged aircraft and talking to surviving crew members and wingmen, Atkinson concluded that airplanes were taking hits and still flying, only to crash because of the fuel system fires and explosions ignited by incendiary ammunition and because of flight control damage.

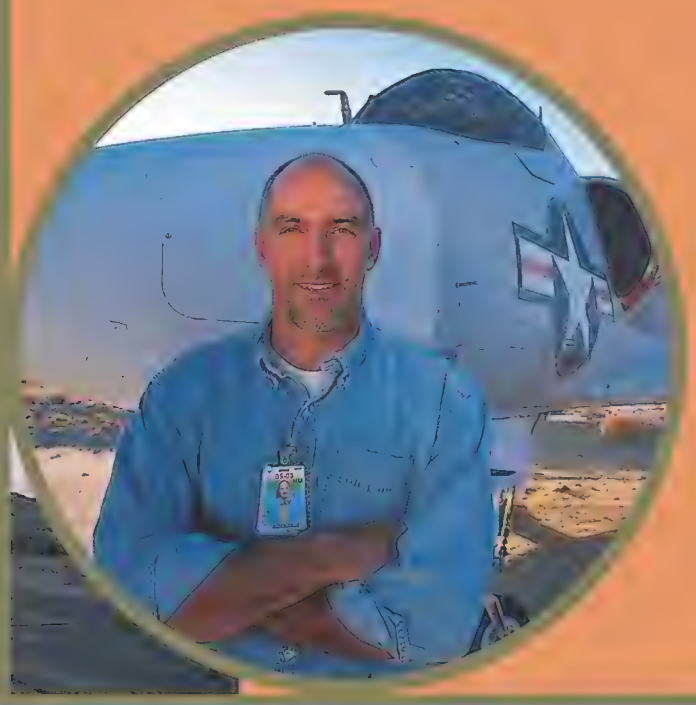
Back at the lab, Atkinson and his colleagues began conversations with engineers at the Army's Aberdeen Proving Ground in Maryland and the Navy's laboratory at China Lake, establishing an informal interservice network of people concerned about decreasing the vulnerability of U.S. aircraft. In 1970 China Lake conducted its first vulnerability test, on a McDonnell Douglas A-4 Skyhawk, and a year later Atkinson's network officially became the Joint Technical Coordinating Group for Aircraft Survivability. Its research, tests, and recommendations proved effective. F-4s, for instance, were modified late in the war with self-sealing fuel lines and tanks and redundant and independent hydraulic systems.

But it's one thing to modify operational aircraft based on combat experience, another altogether to design and build survivable aircraft from the start—and prove their robustness through live-fire testing in the laboratory. Indeed, says Atkinson, who retired in 1992 from his position as staff assistant for survivability and battle damage in the Office of the Secretary of Defense, "aircraft design takes so long that we were able to make those changes on the F-4 only because the war went on for so long." Even as Atkinson's coordinating group pushed for survivability and live-fire testing to be made

The survivability lab is only one of the operations occupying the Navy's vast proving ground at China Lake. Jay Kovar (opposite) has been the lab's director since 1983.



To test aircraft under simulated flight conditions, the lab uses four General Electric TF-33 P11 engines (used on KC-135s) ducted through a single nozzle.



U.S. NAVY

Center: A live-fire test on a North American F-86. During the Vietnam War, engineers looked for ways to toughen aircraft against ground fire and surface-to-air missiles. In the 1980s, tests on operational fighters like the F-15A (above) revealed that hydraulic fluid once believed to be safe is flammable under pressure.

an integral part of aircraft design, events conspired against them. The Vietnam War ended. "When there's no war, people's interest in survivability just dies out," says Atkinson. At the same time, the Air Force left Vietnam determined to modernize its fleet. But rather than focusing on vulnerability—"Can he kill me?"—the service decided to try solving the first problem in the survivability progression: "Can he see me?" Stealth technology claimed billions of post-Vietnam development dollars. "All the services tried to take money out of vulnerability and testing," says retired colonel James B. Sebolka, former military assistant to the director of live-fire testing in the Office of the Secretary of Defense. "Everyone wanted stealth. The thinking was: If we could avoid getting hit, no worries."

Reducing vulnerability was perceived as adding weight and complexity at the expense of performance and cost, pricey insurance for a benefit whose success in combat is difficult to quantify. "A program manager's whole career is dependent upon staying within cost and meeting timelines and performance requirements," says Sebolka, "and there's no incentive whatsoever to say 'Hot damn! I want to see the most rigorous live-fire program to save some GI who goes to combat 15 years after I retire.' "

The result: "We fielded the F-15, F-16, F/A-18, AV-8B, the M-1 tank, and the Bradley Fighting Vehicle [in the late 1970s and early 1980s], none of which had seen combat or ever been realistically tested in full combat conditions," says Jim O'Bryon, director of live-fire testing and deputy director of operational testing and evaluation in the Office of the Secretary of Defense until his retirement last year. In 1984, concerned about the vulnerability of those expensive, virgin weapons systems, Sebolka, Atkinson, and the live-fire gang on the Joint Technical Coordinating Group for Aircraft Survivability pushed through funding for the Joint Live Fire Program, the first program for methodically testing already fielded systems. Vulnerabilities were immediately uncovered: In 1987 China Lake testers discovered that the AV-8B Harrier—an airplane designed for close air support—"was the world's most vulnerable airplane to small arms," says Chuck Myers, "an airplane we never would have bought if it had been subjected to live-fire tests." As the Harrier lifts off, it produces very hot engine downdraft adjacent to hydraulic lines, so if bullets hit the hydraulic lines, says O'Bryon, "you've got a ready-made fire, all while you're hovering, so you're in the worst possible situation." The fixes suggested for the Harrier were "either too costly, too heavy, or too difficult to implement," according to Joe Manchor, who worked on the program. "The AV-8B is the classic example of why vulnerability testing should be done early," he says.

But what really changed the world of survivability testing was the Bradley Fighting Vehicle, an armored troop carrier built of highly combustible aluminum. Incensed by the Army's failure to test the Bradley realistically, Congress passed the Live Fire Test Law in 1986. The law requires survivability testing on all weapons systems, including airplanes, in realistic, full-up, armed configuration before they can proceed to full production. Finally, two decades after airplanes began falling out of the skies in Vietnam, the survivability and live-fire engineers at places like China Lake had the law to back them up.

"I can't think of anything more fun than burning things up and exploding things!" says J. Hardy Tyson, standing next to an F/A-18E Super Hornet that looks like it lost a fight with a fire-breathing dragon. It's the day before the MH-60 test, and Tyson, a survivability test engineer sporting wraparound shades, and laboratory director Kovar are showing me around the lab's boneyard. They've clearly been busy: I see F-4 Phantoms, F-14 Tomcats, F-16 Fighting Falcons, and UH-1

Opposite: Albert Bermudez prepares the remotely controlled gun to fire at the MH-60S (above). Among the projectiles fired is a transparent, cylindrical sabot (opposite, inset), which holds small metal cubes, simulating flying fragments. Top: J. Hardy Tyson with Christine, the F/A-18E/F he riddled and toasted.

Hueys destroyed by Stingers, along with AV-8B Harriers, V-22 Ospreys, AH-1 Cobras, and an assortment of unrecognizable scraps, wings, and tails, all blackened and perforated. Tyson's exuberance (and the evidence) notwithstanding, I'm disappointed to find out that I won't be seeing a hail of rockets and anti-aircraft artillery shells blowing multimillion-dollar fighters into confetti. Tyson and his colleagues are scientists and engineers, after all, and every test is exhaustive. "Each test shot," says Kovar, speaking slowly, taking care with each word, "often takes months to set up and ends in a matter of seconds."

Long before the projectiles start flying, the engineers at China Lake review a STAR—system threat assessment report—which outlines the threats an aircraft is expected to face in combat. (Only threats that have a less-than-100-percent chance of a kill are tested.) Using computer models, engineers determine the paths of specific shots and which shot lines would "cause the aircraft to die," as Tyson puts it. "We ask the modelers to figure out how to hit the component, and just what the probability [of that part's failure] is if you're flying at certain speeds, altitudes, and angles." Then comes the delicate balancing act: Engineers must design ways to shoot bullets and missiles and explode fragments at aircraft operating under conditions that are life-like yet so precisely controlled that the tests don't destroy the test article too soon.

Tyson began testing components of the Super Hornet in 1993, long before the first one was built. Live-fire tests on earlier F/A-18 versions had identified persistent fire problems, especially from shots to the fuel tanks along the airplane's keel. To experiment repetitively with tests that might eat airplanes like a kid eats cookies, Tyson and a team of engineers at the lab built a full-size steel replica of the F/A-18 belly, using a design created by Northrop Grumman and imitating the Super Hornet's fuel cells and dry bays (empty spaces adjacent to fuel tanks through which fuel lines pass). They mounted the replica in the lab's giant high-velocity-airflow system, which uses four jet engines to mimic inflight airflows of up to 500 knots (575 mph) over various parts of the airplane, to study how fire spread in the vicinity of the tanks. Their eventual solution: a fire protection system in which a small rocket motor floods the bays with inert gases, a system similar to that which inflates car air bags. Today, the Super Hornet and V-22 Osprey are the first aircraft to have full dry-bay fire protection. In 1996 Tyson got a full-size wing, a year later he got an engine, in 1998 he got four F/A-18As to play with, and six years after starting he got his first genuine F/A-18E, a now-blackened boneyard hulk nicknamed Christine, after the indestructible vintage car in the Stephen King novel of the same name. But by that time all the development work had been done; Christine merely verified it.

"We did a series of seven tests on her," Tyson says, leading me around the airplane, "and you can see different areas that have been impacted." That's an understatement. One wing's leading edge has a hole wide enough to step through, more holes riddle the engine nacelles and intakes, and the belly is as blackened as the inside of a fireplace.

Tyson's long series of tests—622 shots in seven years—identified not only the repercussions of bullet-ignited fires in the fuel tanks, engine nacelles, and dry bays but also a weakness on the horizontal stabilator's attach points. All the components were redesigned, and Tyson shows me a video of the results. Christine is mounted on the test pad and air is flowing around her at several hundred miles an hour; bullets punch through the airplane; fires flare in the racing wind, then miraculously disappear. Cameras mounted inside the wings and fuel tanks show blackness, roaring fire, and then blackness again—all in half a second.

Between the Super Hornet and a Vietnam-era F-4 Phantom, there is no comparison: A Super Hornet has self-sealing polyurethane fuel tanks located away from ignition sources; short, self-sealing feed lines; redundant fuel pumps; wing tanks lined with open-cell foam; fire extinguishing systems in its dry bays; fire walls between the engine and the auxiliary power unit; redundant flight control computers with four

separated electrical signal lines to actuators; and redundant, independent, and separated hydraulic power systems. Despite being 25 percent larger than the earlier F/A-18 Hornet, the Super Hornet's vulnerable area is the same. Says Tyson: "The F/A-18E/F is the most thoroughly tested and aggressively protected tactical aircraft in the U.S. inventory."

Yet only 34 of the 622 shots in the Super Hornet survivability test program were shot at a genuine Super Hornet, and even then, the aircraft was never loaded with the munitions it would carry to battle. This testing history highlights an important part of the legislation requiring live-fire testing: The 1986 Live Fire Test Law allows a waiver from realistic, full-up, systems-level testing if it would be "unreasonably expensive and impractical." Had E/F hardware been used exclusively, according to live-fire test engineers, the tests would have cost several millions more than the $60-million-plus spent on the program, which, they say, met the ultimate goal—understanding the vulnerability of the aircraft's various systems.

"In order to be granted a waiver," notes Tim Horton, the head of the Survivability Division at China Lake, "the service, the defense department, and Congress must first approve a comprehensive alternative to a full-up test program that ensures the system will be tested adequately to meet both the spirit and intent of the law. In the case of the F/A-18E/F, a waiver was approved at all levels."

But to Jim O'Bryon, the waiver process is a loophole, through which every aircraft program has been slipped since passage of the law. "What you want to learn in live fire is what you'd learn on the first day of combat," says O'Bryon, "but the services hold that if they test all the pieces and use modeling and simulation, that means they've tested it all. But it's not true. Not a single model based on physics exists today that can predict the effect of fire, the number-one killer. And you can't do user casualty estimates from doing component testing. Can you predict how a car is going to react in a crash by testing the bumper alone? You have to test the whole thing."

The day after my tour of the boneyard, I meet up with Manchor in the K-2 test pad control room. After the shot is fired, Manchor will try to run the helo at full power for 30 minutes—to simulate the time it would take for a pilot and crew to make it back to friendly territory.

"Okay, starting engine one," says Chris Fisher, toggling a switch beneath a computer monitor displaying the helicopter engine's vital signs. One of the five television screens shows the helo in full view, its rotors starting to spin. "Good start on one," he says. "Moving to two." The rotors spin faster, and Manchor watches oil pressure and engine temperature rise. Computers have already modeled the effects of this shot at the control link, and real shots have been fired at identical links under load in a static test stand, but those tests don't show what this test will: what happens in response to a hit when all the forces are at work on the MH-60 in a hover. "We want to see if it fails, and if it fails gracefully or catastrophically," says Manchor. A graceful failure means that even if it breaks, nothing else happens and the helicopter continues to fly.

U.S. NAVY

The possibility of a catastrophic failure is the reason we're hunkered down behind steel plates. The link could fail and start a cascade of other, far more deadly failures. Tests on the AH-1 Cobra are a classic example. Shots at the rotor blades and rotor drive controls under static load produced no surprises. But the results were very different when in 1996 the WSL conducted the first test of fast-moving rotor blades and rotor-drive train components while the Cobra was strapped under full power in a hover—a helicopter's most stressful flight envelope. (The test was conducted not to teach the engineers how to improve the survivability of the helicopter but to develop methods for testing rotor components.) A video of the test shows shots at the end of the blades taking out chunks but affecting no other part of the helicopter; a shot near the rotor root, however, caused the rotor system to start vibrating, and in milliseconds the blades, traveling at 500 mph, sliced through the helo's tail while the rotor mast transmission went flying 600 feet. One shot and the Cobra was dead.

In a few minutes Fisher pushes the helo to full power and lifts it off. Air bags atop and below four attach points deflate slightly, leaving the MH-60 in a hover. When Manchor sees the red dot of a gun-mounted laser reflecting off a piece of tape on the control link, which is spinning at some 250 revolutions per minute, he nods. "Start sequence," says Tim Taylor, who is operating the firing system. "Five, four, three, two, one…"

Exactly what happened 0.0012 second later is classified, but Manchor will say that the tests showed "nothing unexpected," and later, at the China Lake boneyard, I can see from a distance that the MH-60 is intact.

Over the next three years Manchor's tests will grow potentially more destructive (when he starts shooting the rotors themselves, for example), and it seems hard to fault their realism. Then again, this is a helicopter, which is expected to fly into the kind of threats it's being tested against. What worries people like Chuck Myers and Jim O'Bryon is that new stand-off precision weapons and low-observable technology may make people think they'll never get hit, undermining the work at China Lake. "People on [the Joint Strike Fighter] say the plane will never have to fly lower than 15,000 feet," says Myers. "But the day will come when it's daylight and overcast, and you've got troops fighting other troops in jungles or forests or a city, and you'll have to. In peace people think you'll never get hit. But I flew B-25s in World War II and got hit. I flew F-9s off carriers in Korea and I got hit. If your testing causes improvements that extend the time you can stay with your aircraft for three to 10 minutes, man, that's a big thing!"

Just how big was proven in early March, when U.S. and Afghan forces attacked al Qaeda and Taliban holdouts in one of the biggest battles of the Afghan war. Seven Apache helicopters provided close air support. The Apache had been subjected to—and redesigned based on—live-fire testing. All seven helicopters were hit. And all seven managed to limp home.

Joe Manchor (opposite) in the cockpit of the MH-60S prototype. Live-fire tests on the helo were begun early enough for results to be incorporated in its design. Lab engineers are using a retired AH-1S Cobra (above) to evaluate shields that lower infrared signatures. The F/A-18 Hornet (top) was the Navy's first aircraft in which survivability dictated elements in the design.

Photo courtesy of NASM

SUBJECT Factory employees take a moment for posterity next to their 5,000th B-17

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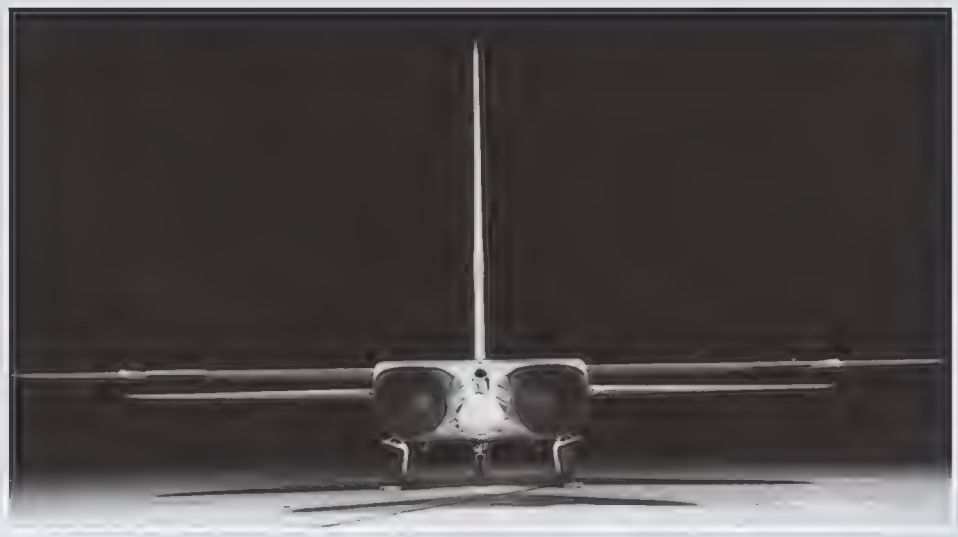
Resto

Mach 2 Heavyweight Champion | North

"It's not just a committee, it's a community," says Patty Mahany, describing the efforts of a Sanford, Florida group restoring a North American RA-5C Vigilante reconnaissance aircraft for display in a park at Orlando-Sanford International Airport. The Vigilante began as a nuclear bomber and ended up launching off carrier decks to fly Mach 2 reconnaissance missions over North Vietnam.



Developed in the late 1950s and initially designated A3J-1, the "Vigi" made its first flight on August 31, 1958. While production of the A-5A was under way, North American Aviation began work on the A-5B, which had additional fuel capacity and other upgrades. Among other innovations, the Vigilante was the Navy's first production aircraft with an operational head-up display for the pilot, as well as the first U.S. production aircraft to introduce fully-variable-geometry intakes for its two General Electric J79-GE-2-8/10 turbojet engines. In 1960, an A-5A set a world altitude record when it zoom-climbed its way up to 91,451 feet.

The Navy ultimately abandoned its dream of a strategic nuclear force operating from carrier decks—the submarine-launched Polaris missile gave the service a better tool in the strategic nuclear business—but the Vigilante was ideal for reconnaissance. Crewed by a pilot and a reconnaissance/attack navigator, the RA-5C photo-reconnaissance model became the version made in the greatest numbers, with just over 100 built or produced by the conversion of earlier Vigilantes.

"Landing the A-5 on an aircraft carrier was quite an experience," says retired Navy commander Don Brumbaugh. "It was a heavy aircraft [nearly 80,000 pounds maximum takeoff weight] with a high approach speed. Being a landing signal officer instructor, I can confidently say it was the hardest aircraft to land aboard the

Vigilante no. 156632, retired in Sanford, went all to pieces in the hangar (below). In 1964, a trio of RA-5Cs had central Florida covered (opposite).

A sculptor's-eye view (top); a Vigi comes aboard the Independence *in 1971 (above). A former target and its rescuers in Sanford, Florida (above, center); the vertical stabilizer parts ways with the fuselage (right).*

American RA-5C Vigilante

carrier. Night carrier operations were particularly tense, and I can honestly say I never got used to them. I was darn near shaking every time I climbed out of the cockpit at night."

"It was initially discomforting when you put the canopy down," says Bob Thomas, a former reconnaissance/attack navigator. "Apart from those two little windows, you really felt shut out from the outside world. You learned to view the world through your radar. You developed other senses to fill in. When something goes wrong, like a generator problem, you learned to detect it from the very slightest sound in your earphones." Thomas later moved on to the F-14, in which he "discovered what it was like to see out."

Sanford is where every Vigilante crew trained, from 1960 to 1968. The Orlando-Sanford Airport was a naval air station from 1942 to 1968 (with a five-year respite between World War II and Korea) and trained pilots in three wars. Three years ago there was not one landmark in the town commemorating the long Navy presence. Promoting Sanford as "Celery City"—a sobriquet less accurate today than it was 90 years ago—was wearing thin for the local chamber of commerce.

During a chamber meeting two years ago, Captain Jack Dow, a retired A-6 Intruder pilot, was named president of the Memorial Committee. "We wanted to avoid mistakes of the past," Dow says. "There had been two disappointing attempts to find a Vigilante and restore it. We wanted to do better."

The National Museum of Naval Aviation at Pensacola, Florida, identified an RA-5C Vigilante at China Lake, California, that could be salvaged. "The Navy had been using the plane as a target," Mahany says. The Memorial Committee is now rebuilding the aircraft in a hangar at the Sanford airport and preparing to mount it in an airport park dedicated to the town's naval aviation heritage. "We're about halfway finished," says Mahany. "The committee is working on corrosion control and preparing to paint, and after that the wings and the horizontal and vertical stabilizers will be reassembled. There's a Vigi reunion here next May, and we promised to have the aircraft ready for dedication."

The Sanford airplane is number 156632, the 12th from last aircraft in the RA-5C production run. If you flew or worked on Vigilantes, especially 156632, the committee would like to hear from you. Contact Patty Mahany, Sanford Airport Memorial, One Red Cleveland Blvd., Suite 1200, Sanford, FL 32772, or e-mail *smahany@aol.com*.

—Robert F. Dorr

B&W PHOTOS: U.S. NAVY; COLOR PHOTOS: NAVAL WEAPONS STATION, CHINA LAKE, CA

Project 921

Russia and the United States have held the inside tracks in the space race. In the stretch, here comes China.

by Joe McDonald

The heart of China's ambition for a high-tech future lies on the north side of Beijing's Haidian district, near the leafy campuses of Peking and Tsinghua Universities. Clustered around those elite schools and a flock of smaller colleges are dozens of start-up companies working in the hot fields of information technology and genetics. The communist government has optimistically dubbed the crowded district China's Silicon Valley.

To the south, hidden behind high walls and armed guards, are government research centers and the laboratories of the People's Liberation Army. And if foreign experts are right, somewhere in this military-run section of Haidian, a group of fighter pilots is training to fulfill China's most audacious goal—launching an astronaut into space.

The Chinese astronauts-in-training, their identities still secret, are mystery figures at the center of the country's decade-long push to become the third nation to send its own people into orbit. The state press says astronauts should carry China's gold-starred red flag into space by 2005, and some Western analysts think it could happen as early as next year. But even though early tests of a three-person spacecraft have been successful, the government has told its citizens and the world little about its pursuit of this expensive, cold-war-style propaganda prize. The secretive Chinese military dominates the program, and, fearing the political embarrassment that could come with setbacks, the government stays mum.

"We don't really know much," says He Shuzhang, retired director of the Aerospace Museum at the Beijing University of Aeronautics and Astronautics in Haidian, one of the country's top rocketry schools. The astronaut training center is thought to be near the museum where He—pronounced "Huh"—still helps out. When asked if he knows exactly where, he shakes his head. But despite the shortage of information, "ordinary Chinese care a lot about this and have high hopes," he said. "They feel great pride."

China has long held ambitions for a place in space. The country sent up its first satellite in 1970, which broadcast a tinny version of the communist Chinese anthem, "The East Is Red." Even before then, when Americans and Soviets were racing each other to the moon in the mid-1960s, the Chinese began working on plans to enter the derby with a one-man capsule named Shuguang, or Dawn. The project got as far as selecting 19 astronaut candidates in 1971, with an eye toward a first flight two years later. But coming as it did during the political upheaval of the 1966–1976 Cultural Revolution, when key engineers and scientists were being denounced and ousted from their positions, the effort was likely doomed from the start. That first cadre of astronauts was disbanded within a year, and the project was finally scrapped in 1980.

Chinese interest in human spaceflight simmered for another decade or so, but only simmered. Former U.S. astronaut Gordon Fullerton recalls a goodwill visit to China following his shuttle flight, STS-3, in 1982. His hosts were polite, but very guarded about whatever plans—past or future—they had to build up an astronaut corps.

Have rocket, will travel. Chinese technicians position the astronaut vehicle Shenzhou on a Long March launcher prior to its second test flight in January 2001.

AFP PHOTO/XINHUA

"That was super-secret," he recalls. "They weren't saying anything." Fullerton and fellow STS-3 astronaut Jack Lousma were treated to lab visits, where they saw, among other things, a centrifuge (the Chinese were disappointed to learn that U.S. shuttle astronauts no longer used them for training). But "there wasn't anything close to a computer," says Fullerton. And beyond a trip to a rocket factory and a space medicine institute, the American visitors saw little evidence that the Chinese were planning to get into the spaceflight business.

When political stability returned to China in the 1990s, along with economic growth, the old dream was resurrected. The current bid to send astronauts into orbit is called Project 921: "92" for the year it began and "1" designating it as the first major, long-term national project begun that year.

Much has changed since the aborted Shuguang program of the 1970s. China now does a thriving business firing satellites into orbit for foreign customers aboard its Long March rockets. Western analysts say the country's rocketry skills are among its strongest military technologies. Though the average citizen makes less than $700 a year and the country faces crushing demands for money to overhaul state industry and fund social programs, the government appears ready to spend what it takes not just to achieve manned spaceflight but to sustain it.

"This is a matter of national pride," observes Joseph Cheng, director of the Contemporary China Research Center at the City University of Hong Kong. "We were the most civilized country centuries ago, and we must recapture this glory." Space travel is a powerful international status symbol, says Cheng, a way of demonstrating that China offers an alternative to American leadership. "China is a major power, and has to be respected as a major power." He chuckles as he quotes a maxim from communist party founder Mao Zedong: "Even if we don't have trousers, we still want the atom bomb."

Former museum director He, a quiet, slender, 72-year-old man with a thick shock of salt-and-pepper hair, recalls the patriotic stirrings he felt in July 1969 on hearing that an American had set foot on the moon. China, the country that invented rocketry, was then in the grip of the Cultural Revolution, terrorized by violent, radical gangs that were incited by Mao. The economy was collapsing. Scientists were harassed for past contacts with foreign researchers. Still, says He, "I thought right then, if the Soviets had sent someone into space, and the Americans did it, then we certainly would do it."

With that goal now clearly in sight, a sketchy picture of Beijing's astronauts—called *yuhangyuan*s, which means, roughly, "one who goes into space"—is slowly emerging from the shadows of official secrecy. The government won't allow any of the flashy publicity that turned NASA's Mercury astronauts into celebrities even before they flew. The China State Manned Aerospace Office in Beijing declined even to accept a written request for information for this article. But the authorities have stopped short of a total, Soviet-style information blackout. In a sign of growing official confidence, the state-controlled press has been divulging more details about the project since the third successful test of Shenzhou (pronounced "shun jo"), the astronauts' bowl-shaped reentry capsule.

In that test, conducted last March, Shenzhou orbited Earth 108 times, then touched down in the grasslands of inner Mongolia. Afterward, state television showed jubilant mission control technicians in red jumpsuits leaping in the air and cheering as military officials nodded approvingly. The government proclaimed the seven-day test flight a success and said the reentry capsule, which had carried sensor-equipped, spacesuited mannequins into orbit, was "technically suitable for astronauts." Another section of the spacecraft remained aloft; ground controllers have been using it to practice remote-controlled orbital maneuvering.

The *yuhangyuan*s, picked from among some 2,000 military pilots in the People's Liberation Army, are all around 30 years old, according to stories in the state-controlled press, which are useful, if unverifiable, sources of technical information. The official Xinhua News Agency has given the number of astronauts as 12, while other reports put the number at 14, perhaps counting trainer astronauts as well. In 1996, China paid Russia to put two pilots through its Cosmonaut Training Center in Star City on the outskirts of Moscow. It is unclear whether the two

AFP PHOTO EPA/SERGEI CHIRIKOV

THIS PAGE *China's Project 921 is Russian-based. Prime Minister Zhu Rongji visited Russia's cosmonaut center last year.*

OPPOSITE PAGE *1984 propaganda poster from the country that invented rocketry.*

Though the average citizen makes less than $700 a year, the government appears ready to spend what it takes to achieve manned spaceflight. As Mao said, "Even if we don't have trousers, we still want the atom bomb."

men—identified in Western reports as Li Qinglong and Wu Zi—were preparing for a Shenzhou flight themselves, or whether their role has been limited to training other Chinese astronauts back home. Either way, China is unlikely to continue relying on Russian help in this area. Most Western analysts agree with Phillip Clark, an independent aerospace consultant based in England, that Beijing is intent on building up its own space school. Clark's specialty is Russia, but he has followed the China space program since the 1970s, in part for the challenge—"It's too easy to get information on other countries," he says.

Judging by the press accounts, Chinese trainers followed Russian tradition in selecting diminutive fliers to fit inside a cramped capsule. The first candidates average five-foot-seven and 110 pounds, small by the standards of today's well-nourished Chinese youth. The state press says the government will announce their names after the fourth test flight, suggesting that Shenzhou 5 might be the first to carry a crew. By contrast, when Yuri Gagarin became the first human in space in 1961, Moscow didn't reveal his identity until he was safely in orbit. And when program officials selected Gagarin for the flight, they withheld that information from him until a few days before launch. The Chinese will follow that practice, according to one Chinese report.

In an article last April, the weekly newspaper *China Space News* revealed new details about the *yuhangyuans*' training. Members of the corps live Monday to Friday in a heavily guarded building at an "aerospace city" in Beijing. "Any outsiders who try to peek in or take pictures are politely asked to leave," the report said. State newspapers have begun calling the building the Red Chamber. On weekends, according to *China Space News*, the astronauts return to their families, who live in ordinary apartments in the city. Many of the pilots' wives work in the same facility, said the newspaper, and "as wives of astronauts, have a strong sense of secrecy."

Additional glimpses of the program have come from other state media. An account last year in the *Guangzhou Daily* mentioned a four-story windowless building on Beijing's west side that held a mockup of the Shenzhou reentry capsule. The story described white-robed technicians watching as a trainee in an orange spacesuit climbed into the capsule simulator.

The astronauts practice emergency launch pad escapes at the launch site in the Gobi Desert, according to the state newspaper *Labor News*. The base is near the remote northwest town of Jiuquan, a former oasis stop for camel trains on the ancient Silk Road. (China has two other launch sites, which so far have been used only for launching satellites—at Taiyuan in the central province of Shanxi and at Xichang in the southwest province of Sichuan.)

The program has a distinctly Chi-

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nese identity. The astronauts will conduct inflight experiments in traditional herbal medicine, according to capsule designer Su Shuangning, who gave a rare interview last April to the *People's Liberation Army Daily*. The space cuisine will likewise have a native flavor. A research lab in Shanghai has developed a 21-meal menu, according to *China Space News*, whose reporter saw dozens of space-bound dishes at the Beijing training center—light on fish, meat, and bread and heavy on curried rice, shellfish, vegetables, and other dishes prepared by adding hot water. The diet will also include dried fruit. And "since Chinese love to drink tea, besides orange juice, there is iced tea and green tea," the newspaper said.

Because the identities of the astronauts and engineers are largely unknown, the most visible figure in China's nascent space program has been President Jiang Zemin. The 76-year-old leader, who also heads the Chinese communist party, is expected to start giving up his formal posts over the next two years, and is using the space program to polish his image as a leader who modernized China. The former engineer and Shanghai mayor, a surprise pick in 1989 to head the communist party after that year's political upheaval, prides himself on having helped to spread the Internet and other modern technology to the masses. He was on hand at Jiuquan on March 25 for the third Shenzhou launch. State television devoted half of its 30-minute nationwide evening news that day to the event—focusing not on the flight itself but on Jiang. Dressed in a green military-style uniform, he was shown congratulating control room technicians and speaking against a backdrop of fireworks bursting over the Tiananmen Gate in central Beijing.

Under Jiang, the government has largely cast off leftist ideology in promoting economic reform. Instead, it appeals to Chinese cultural pride by advancing projects such as Beijing's campaign to host the 2008 Olympics. When that bid proved successful, millions of people poured into the streets of the capital in spontaneous nighttime celebration, waving flags, singing the national anthem, and cheering themselves hoarse. The space program fits this nationalistic role perfectly. In contrast to revolution-era names—Long March rockets, East Is Red satellites—the more poetic Shenzhou——"Sacred Vessel"—harkens back to the glory days of classical China.

When Beijing won its bid to host the 2008 Olympics, millions of people poured into the streets in spontaneous celebration, waving flags, singing the national anthem, and cheering themselves hoarse. The space program fits this nationalistic role perfectly.

AFP PHOTO/STEPHEN SHAVER

One day last July, I set out looking for the public face of China's new space program. But I ended up disappointed, caught between Beijing's desire to brag about its achievements and the military-inspired secrecy that the communist system regards as a necessary part of its armor. At the Aerospace Museum, former director He and the current director, Han Guoju, were gracious and welcoming. Their exhibits, housed in two concrete-floor halls the size of small aircraft hangars, include a Chinese fighter jet and models of airplanes made by the country's civilian industry. Ultralight aircraft hang from the high ceiling. In one corner is a head-high scale model of a Shenzhou capsule and photos of Long March rockets blasting off. But that's all. "Our museum is very simple," said Han, who recommended that I visit the bigger China Aerospace Museum, on the southwest outskirts of Beijing.

I got directions from a receptionist over the phone, but when I arrived, I found that the museum is inside the walled compound of the state-run Launch Vehicle Research Institute. A polite young guard with an AK-47 rifle told me the public isn't allowed through the front gate. I called back the woman in the museum office, who belatedly explained why I'd never heard of the museum—it was *baomi*—secret. Entry by a foreigner requires permission from the office of the institute director. I waited an hour but was finally told that I'd been refused.

As I left, I saw the clash between China's high-tech hopes and low-tech reality: On the street outside of the building, farmers drove horse-drawn wagons filled with vegetables to street markets.

The cost for this huge but still-developing nation to create a space program from scratch—the state press says it now involves some 3,000 government agencies and companies—is a mystery. Foreign estimates range into the billions of dollars. But one Western diplomat in Beijing who follows the program says the total could be less than $1 billion, or half of what NASA paid to build a single space shuttle orbiter. "Wages for engineers and

THIS PAGE *Despite government secrecy about the astronaut flights, "ordinary Chinese care a lot about this," says former museum director He Shuzhang.*
OPPOSITE PAGE *Mission Control in Jiuquan—once an oasis stop on the Silk Road, now the Long March rocket's point of departure.*

OPPOSITE: AFP PHOTO

other experts are very low," says the diplomat, who spoke on condition that he not be identified. "And materials and techniques that the Soviets and Americans had to spend a lot of money to develop in the 1950s and '60s are common knowledge."

Chinese media also emphasize the project's frugality. A report on the Web site of the communist newspaper *People's Daily* said designers of the rocket assembly building at Jiuquan—whose 240-foot-high front doors weigh 350 tons—saved some 40 million yuan (about $5 million) by constructing it of concrete rather than the costlier steel used by Russia and the United States. Still, a few hundred million dollars spent on one building is equivalent to a full year's budget for a Chinese province—money used for roads, schools, and health care in a country where hundreds of millions of people live in poverty.

Beijing cut some corners by buying Russian know-how, and is believed to have purchased a Soyuz capsule, docking system, and spacesuit to study. Clark, the British expert, says China might also buy, as another study aid, a life support system designed for Russia's former Mir space station. The United States, on the other hand, has provided no technical help. Washington accuses Chinese companies of exporting rocket technology to Iran and Pakistan and worries that Beijing's own rapidly improving missile arsenal could threaten Taiwan. So, until the U.S. Department of State says different, NASA will likely keep a cool distance. Lynn Cline, NASA's deputy associate administrator for external relations and an experienced diplomat, says that Chinese officials occasionally ask her at international meetings what it would take to join the International Space Station project. But they've made no formal request, and cooperation remains limited. NASA is scheduled to carry a Chinese student experiment into orbit on the space shuttle this fall, and the two countries have discussed joint projects in Earth science and other non-controversial fields.

AP PHOTO/XINHUA, LI GANG

Even so, Chinese researchers have had access to U.S. expertise through technical conferences—more access, in fact, "than makes a lot of people in the West comfortable," according to Charles Vick, chief of the Space Policy Division of the Federation of American Scientists. There has been more of a clamp-down since September 11, he says. "Government buildings such as NASA are now off-limits," and U.S.

conferences are imposing restrictions. "They're being turned away and told, flatly, 'No.' "

Chinese space officials are proud of their mostly homegrown program. "Our late start doesn't necessarily mean we are developing slowly," said capsule designer Su in his April newspaper interview. "We can learn from the experience of others and take shortcuts." In fact, China's first space hardware will be far more sophisticated than the capsules launched by the Soviets and Americans in the early 1960s. The 8.4-ton Shenzhou is slightly bigger than the Russian Soyuz vehicle on which it was modeled. Photos of Shenzhou 3 on the launch pad show improvements added by Chinese designers, including steering rockets, presumably to be used for docking with a space station that China also plans to launch sometime in the next decade.

News reports have said that the first piloted Shenzhou flight will carry two or three astronauts, whereas the Americans and Soviets started out with tiny, one-seat capsules. Still, China is proceeding cautiously, lacking a rival to race against and constrained by tight budgets and safety worries. The government has never disclosed a schedule for launches. "These designers are going to be very conservative about their approach because you're dealing with human life here, and the prestige of a nation," says Vick. Clark says that an executive of China's commercial satellite launching company once told him that the test program "can't afford a failure."

Foreign analysts think that Chinese designers got a jarring reminder of the difficulties of human spaceflight after the second Shenzhou test, conducted in January 2001. They say something went wrong on reentry—possibly a partial failure of parachute equipment—and the capsule may have slammed down into the Inner Mongolian steppe. In contrast to the triumphant fanfare surrounding Shenzhou 3, not a single photograph of the capsule was released after the second test flight. "I'm not saying it was destroyed, but it was not something a human being would like to endure," says Vick.

Shenzhou 3 also was delayed on the pad. Vick has seen Western satellite images showing the rocket on the launch pad in August 2001, before it was removed for what he believes were modifications to both the booster and the capsule. The modifications suggest that the Chinese may be struggling to master what engineers refer to as systems integration, or getting all the elements of a space program—from rockets to computers to the four tracking ships stationed at listening posts around the globe—working together smoothly.

Assuming Chinese astronauts make it into orbit sometime in the next couple of years, what then? In their rare public comments, Chinese researchers have talked about wanting to mine the moon and explore Mars—aspirations that the state press stresses don't have the backing of the government. But China clearly wants to go beyond just rocketing astronauts into orbit and bringing them home again. Clark points out that the early Shenzhou tests have already demonstrated that the capsules can reach orbits ideal for the planned space station. They pass over their launch base roughly every two days, which would offer frequent opportunities to send up supplies or switch crews. A second launch pad is under construction at Jiuquan, and that would allow two rockets to be launched within a short interval, carrying capsules to rendezvous with each other in orbit, dock with the station, or perhaps be joined in orbit in preparation for a lunar mission.

Outside observers aren't certain how far China's ambitions for a moon program have advanced—whether it's just a vague notion or a more detailed plan with a timetable. But the idea has a certain logic. "The Russians can't go to the moon [for lack of funds]; the Americans don't have the political will to go to the moon," Clark says. "Really, the Chinese are the only people who could realistically be going to the moon in the next 20 years."

Visitors to the Expo 2000 technology fair in Hannover, Germany, in October 2000 were intrigued by the centerpiece of the Chinese pavilion, a diorama showing astronaut mannequins driving a rover across the lunar surface, having just planted the flag of the People's Republic of China. Coming just 11 months after Shenzhou 1 completed its flawless first flight, the scene didn't look all that farfetched.

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AFP PHOTO

THIS PAGE *Scene from the New China: If plans hold, the third nation to send people into orbit may be the next on the moon.*

OPPOSITE PAGE *Like the Russian Soyuz, on which it was modeled, the Shenzhou reentry capsule lands on solid ground—in the Mongolian grasslands. Astronauts could be on board as early as next year.*

How Things Work:

Supersonic

by Diane Tedeschi | Illustrations by John MacNeill

"We were in a turn and climbing when one of the inlets showed signs of instability. Shortly thereafter—KER BLAM!—the aircraft slammed my head against the side of the cockpit and then momentarily became unstable as it yawed, pitched, and vibrated."

This is an account of a supersonic engine inlet failure, or "unstart," recalled by retired reconnaissance systems officer Roger Jacks in *SR-71 Revealed*, a book by retired Lockheed SR-71 pilot Richard H. Graham. It shows what can happen when a supersonic inlet stops delivering the uniform stream of air upon which efficient jet engine operation depends.

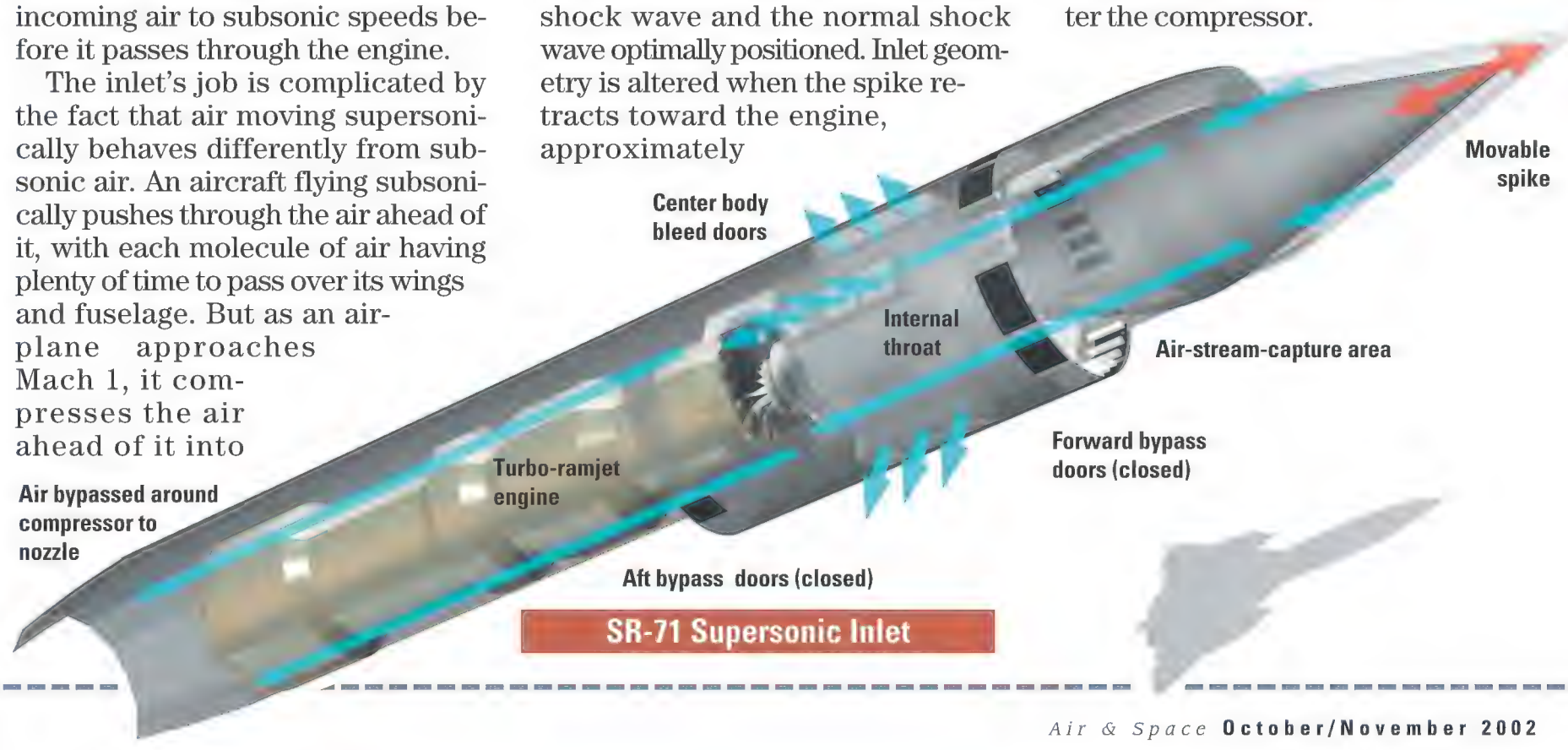
When a jet airplane is flying faster than Mach 1—beyond the speed of sound—the air entering the engines is moving supersonically as well. But no turbojet engine compressor—the rotating disks and blades at the face of the engine that compress the air before it is mixed with fuel—is capable of handling supersonic air flow. The job of an engine inlet is to slow incoming air to subsonic speeds before it passes through the engine.

The inlet's job is complicated by the fact that air moving supersonically behaves differently from subsonic air. An aircraft flying subsonically pushes through the air ahead of it, with each molecule of air having plenty of time to pass over its wings and fuselage. But as an airplane approaches Mach 1, it compresses the air ahead of it into shock waves—bands of air radiating from the airplane that are much hotter and denser than the ambient air.

Turbojet engines cannot digest the shock waves generated by their inlets, so a crucial role of the inlet is to keep the inevitable shock waves positioned so that they do no harm. The SR-71 Blackbird, a now-retired twin-engine reconnaissance aircraft, has an inlet design based on a cone-shaped body, or spike, that generates an oblique-angled, cone-shaped shock wave at the inlet's entrance and a normal shock wave—one rising at a right angle from the direction of air flow—just aft of the internal inlet throat.

As the SR-71 increases its speed, the inlet varies its exterior and interior geometry to keep the cone-shaped shock wave and the normal shock wave optimally positioned. Inlet geometry is altered when the spike retracts toward the engine, approximately 1.6 inches per 0.1 Mach. At Mach 3.2, with the spike fully aft, the air-stream-capture area has increased by 112 percent and the throat area has shrunk by 54 percent.

The cone shape of the spike also incrementally reduces the speed of the incoming supersonic air without producing a drastic loss of pressure. The farther back over the cone the air moves, the more speed it bleeds off. As the slowed, but still supersonic, air continues to move farther into the inlet, the normal shock wave springs up between the inlet throat and the engine compressor—exactly where it is supposed to be. Once there, the normal shock wave slows the air passing through it to subsonic speeds, preparing it to enter the compressor.



SR-71 Supersonic Inlet

Inlets

Lockheed SR-71

Lockheed Martin F-35 Joint Strike Fighter

LOCKHEED MARTIN (2)

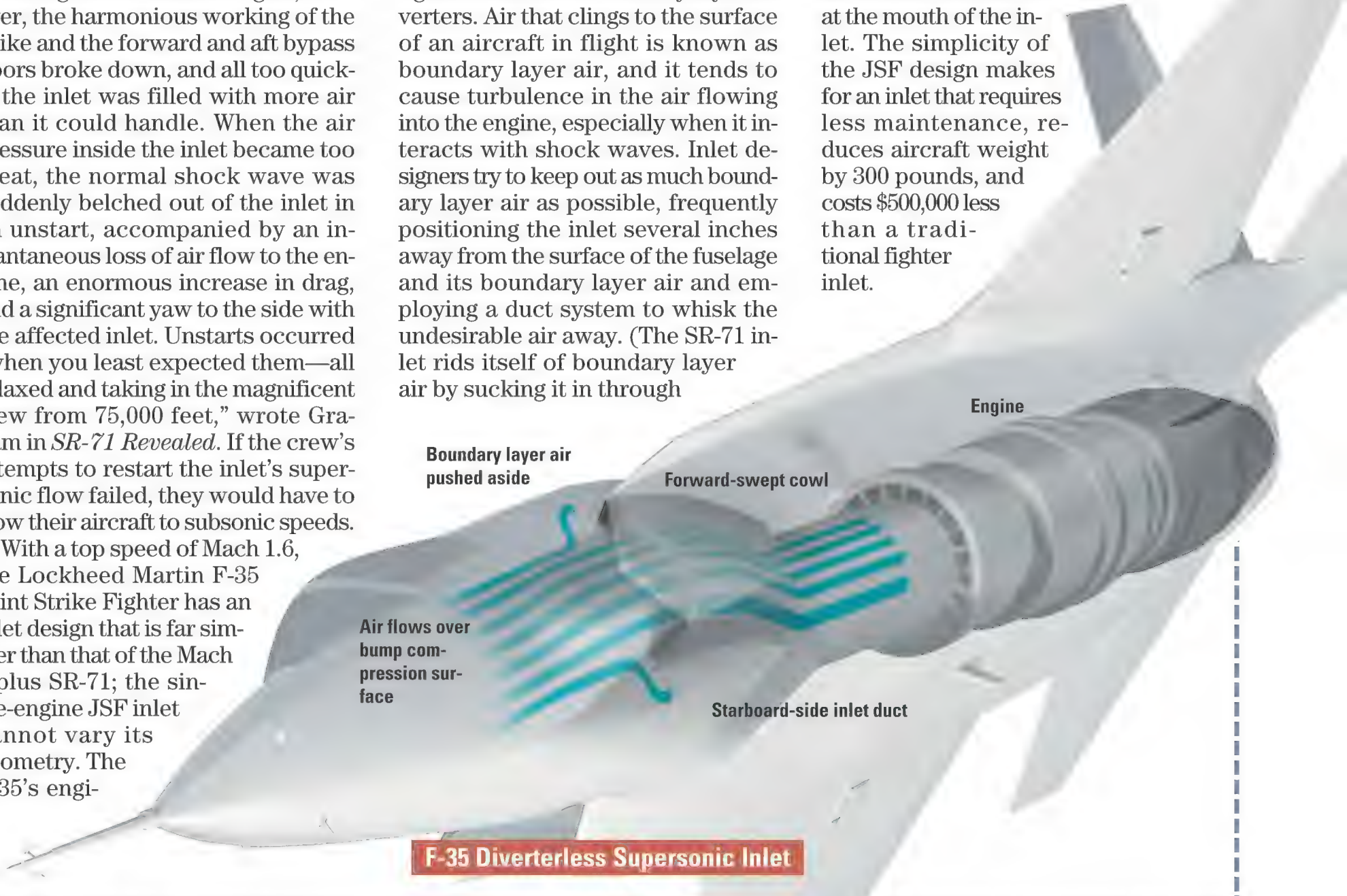
It is a constant balancing act to keep the normal shock wave in the right position. The inlet has an internal pressure sensor, and when it detects that the pressure has grown too great, it triggers the forward bypass doors to open, expelling excess air. The inlet also has a set of aft bypass doors, controlled by the pilot. The forward and aft bypass doors work in opposition to each other: Opening the aft doors causes the forward doors to close, and when the pilot closes the aft doors, the forward doors open in turn.

During some Blackbird flights, however, the harmonious working of the spike and the forward and aft bypass doors broke down, and all too quickly the inlet was filled with more air than it could handle. When the air pressure inside the inlet became too great, the normal shock wave was suddenly belched out of the inlet in an unstart, accompanied by an instantaneous loss of air flow to the engine, an enormous increase in drag, and a significant yaw to the side with the affected inlet. Unstarts occurred "when you least expected them—all relaxed and taking in the magnificent view from 75,000 feet," wrote Graham in *SR-71 Revealed*. If the crew's attempts to restart the inlet's supersonic flow failed, they would have to slow their aircraft to subsonic speeds.

With a top speed of Mach 1.6, the Lockheed Martin F-35 Joint Strike Fighter has an inlet design that is far simpler than that of the Mach 3-plus SR-71; the single-engine JSF inlet cannot vary its geometry. The F-35's engineers could get away with a less complicated design because at vehicle speeds up to about Mach 2, the shape of the inlet itself can slow down much of the supersonic air before it enters the inlet. The JSF inlet is, however, a breakthrough design: It has no diverters. Traditional fighter inlets, such as those found on the F/A-18 and F-22, have slots, slats, and moving parts to divert or channel airflow. The F-15 inlet has ramps and doors that alter its external and internal shape to adjust airflow as needed.

Many other currently operational fighters also have boundary layer diverters. Air that clings to the surface of an aircraft in flight is known as boundary layer air, and it tends to cause turbulence in the air flowing into the engine, especially when it interacts with shock waves. Inlet designers try to keep out as much boundary layer air as possible, frequently positioning the inlet several inches away from the surface of the fuselage and its boundary layer air and employing a duct system to whisk the undesirable air away. (The SR-71 inlet rids itself of boundary layer air by sucking it in through slots on the spike and passing it through ducts that exit the nacelle.)

The F-35 inlet, however, is positioned flush against the fuselage, and just in front of the inlet opening is a raised surface, or bump, that pushes much of the boundary layer air off to the sides and away from the inlet. The bump serves another purpose: During supersonic flight, it compresses and slows the air passing over it into an oblique shock wave. The air is still moving supersonically, however, and it is slowed down to subsonic speeds after passing through a normal shock wave that forms at the mouth of the inlet. The simplicity of the JSF design makes for an inlet that requires less maintenance, reduces aircraft weight by 300 pounds, and costs $500,000 less than a traditional fighter inlet.



F-35 Diverterless Supersonic Inlet

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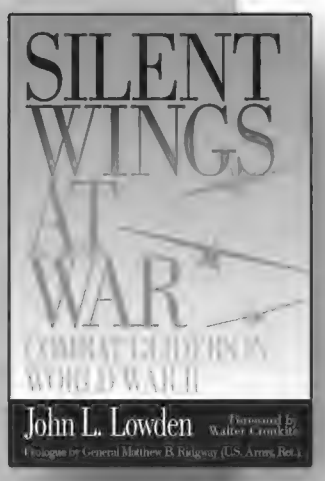

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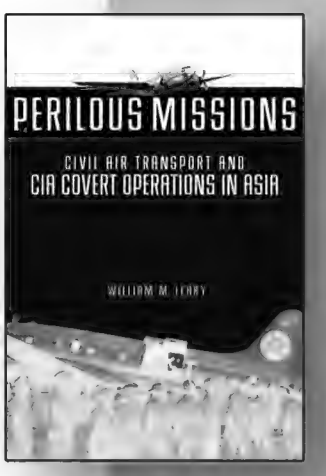

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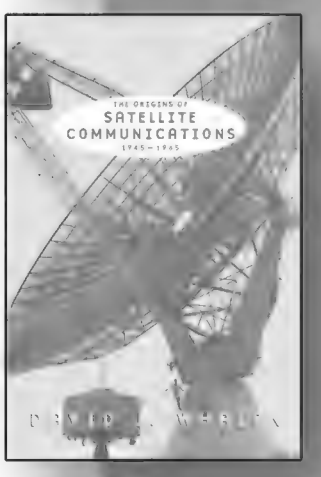

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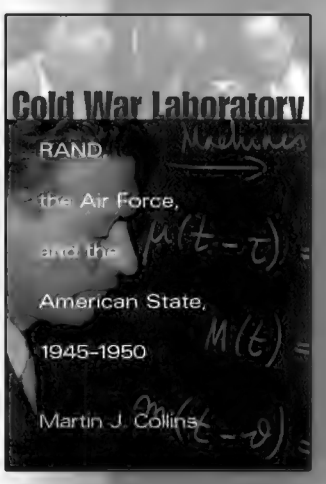

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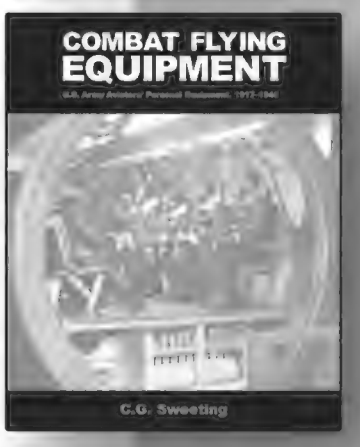

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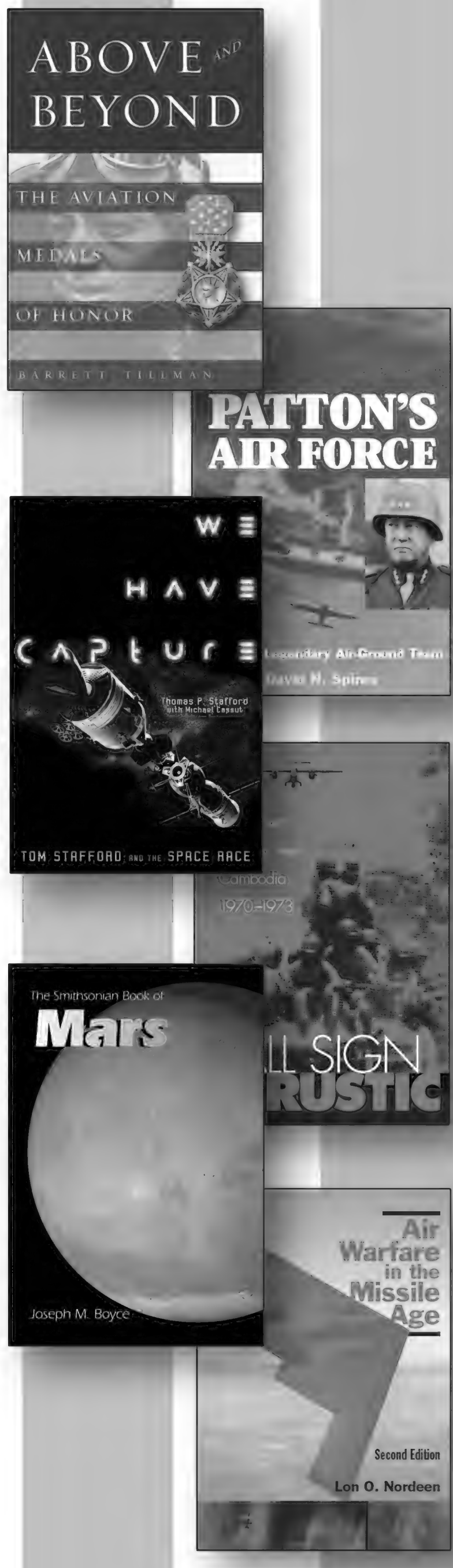

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SÃO PAULO TRAFFIC REPORT

BY CARL A. POSEY

IT'S ROTOR TO ROTOR OUT THERE.

At Sikorsky Aviation's Stratford, Connecticut headquarters, the paneled office where the father of the helicopter spent his final years has been preserved much as it was three decades ago. On the credenza is a copy of Igor Sikorsky's last letter, which the 84-year-old dictated on October 15, 1972, the day before he died. "Please accept my sincere thanks for your recent letter," he wrote Jerome Lederer of the Flight Safety Foundation, "and for the enclosure describing the São Paulo helicopter rescues.... I had it read to me (my eyesight has failed to such an extent that I can no longer read) and found it interesting indeed.

"I always believed that the helicopter would be an outstanding vehicle for the greatest variety of life-saving missions and now, near the close of my life, I have the satisfaction of knowing that this proved to be true."

The helicopter rescues reported to Sikorsky had been made eight months earlier after the 26-story Andraus Building, in the Brazilian city of São Paulo, had erupted in flames. Some 375 people were injured in the fire, but only 16 died. The toll would have been higher but for a swarm of helicopters whose crews scooped people by the hundreds off the rooftop.

The flames that consumed the Andraus Building were not merely destructive. They also released seeds that, through a coincidence of time, place, and technological readiness, would grow into a unique culture of vertical flight, a future for helicopters that not even Sikorsky had foreseen.

High-rise fires in the 1970s (above) gave rise to the helicopter culture in São Paulo, where hundreds of rotorcraft criss-cross the skies (right: Helibras HB 335 Esquilos flying for tire manufacturer Pirelli).

LEFT: BETTMANN/CORBIS; RIGHT: FI AP INTERNATIONAL ARCHIVES

FLAP INTERNATIONAL ARCHIVES

OVER THE NEIGHBORHOOD OF MORUMBI, ONE BEGINS TO SEE RESIDENTIAL HELIPADS, AS BLUE AS SWIMMING POOLS AND ALMOST AS UBIQUITOUS.

Even in the helicopter-saturated world of São Paulo, Donaldo Zandon—Captain Zandon, as he prefers—is an exceptional case. He has spent 18,000 hours flying helicopters, mostly Bells. "I was a captain in the air force," he says, "then I retired and have been flying helicopters ever since." He flew offshore to oil rigs, around town for corporate executives, and in the Amazon for industry—"every kind of flying." At the moment, he occupies the right seat of a Bell 206 puttering over the southwest rim of São Paulo.

A thousand feet above the ground, Zandon guides the 206 out along a river flanking the city, which spreads out to every horizon, the low structures interspersed here and there by a bloom of high-rises. Like many European cities, São Paulo is laid out like a plate of spaghetti; it is also burdened with terrible roads, a rudimentary transit system, and a population of 17 million. On a good day, driving from the city's outskirts to its center is an hour's work; add rain and multiply by four. But at 1,000 feet the clamor is barely discernible. In the distance the posh downtown around Avenida Paulista, bristling with glass and metal towers, clings to a spine of high ground. Heliports dot the cityscape in stunning profusion, like lilies floating on a concrete pond.

Knowing this airspace is shared by hundreds of machines, one expects to see a chaos of them, wheeling like swallows over Capistrano. In fact, while the airspace over the city center can become busy and helicopters do indeed speckle the horizon, the size of São Paulo—it has the sprawl of Los Angeles—keeps crowds from getting too large. Because Zandon is flying close to Congonhas Airport, São Paulo's busy domestic hub, he has the tower on his radio, but there is no controlling voice vectoring his helicopter. "We just look around, speak to other pilots," says the captain. "We have all these corridors to fly. In bad weather, helicopters and pilots must be IFR [on instrument flight rules] to and from the airport. At decision height, you say to the controller, 'I'm in visual conditions,' and you can [leave airport control and] go to another helipad. In minimum conditions you have to land at the airport."

One wonders how the pilots managed to find the right helipad, in this great floating garden of them, before there was a Global Positioning System. The answer: with great difficulty. But they still don't use GPS for instrument approaches because, one pilot notes, "every day we have another antenna, another building." The charts will never catch up.

Over the southwest neighborhood of Morumbi, said to be São Paulo's wealthiest, one begins to see residential helipads, as blue as swimming pools and almost as ubiquitous. There are 20 in this one area, some with an interesting accessory: concealed snipers, to discourage low-flying intruders. The fact that São Paulo has more than its share of murders and robberies, and contends with other South American countries for the kidnapping crown, hasn't hurt the helicopter trade. Trapped in a bog of automotive traffic, a powerful executive or socialite is vulnerable to anyone bent on collecting a ransom. After dark, cab drivers tend not to stop even for traffic lights.

But the booming helicopter culture in São Paulo is not the creation of gridlock, crime, and the way the wealthy forage for convenience. It took root in the ashes of the Andraus Building fire.

Even now, the Andraus fire is never far away. "My father put our three helicopters up saving people," recalls Marco Antonio Audi, who sells helicopters and operates an air transport and taxi service. "We took out 262 people from the roof. One pilot told me that when he arrived over the building, a hundred people were trying to grab the helicopter."

One result of the disaster was the requirement that all public buildings have either a full sprinkler system or a rooftop helipad. The latter not only enhanced fire safety, it added marketability to commercial structures. Paulistanos today take a certain pride in not being able

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MARCIO JUMPEI/FOTO REFLEXO

Business and pleasure: Helicopters do it all in São Paulo, from ferrying visitors to the city's World Trade Center (left) and monitoring traffic on the Marginal Pinheiros to picking up patrons at the Hotel Emiliano.

to fix, from one week to the next, the precise number of helipads in their city, but put the current total at about 250, en route to 400 or more. Manhattan has five.

Not surprisingly, the abundant facilities have attracted a cloud of helicopters. Of about 900 in Brazil, nearly two-thirds operate in and around São Paulo, which has the planet's third largest helicopter population, after New York, with 2,000, and Tokyo, with 700. But no other city is as accommodating to vertical flight as São Paulo, or has a population more inclined to use it. Brazilians are famous for a readiness to transform the technically new and exotic into the tried and true.

Audi Helicopters has certainly found this to be the case. Marco Audi is in an office at the Campo de Marte airport, a large general-aviation field on the north rim of town, where flocks of rotary-wing machines clatter to and from a host of schools and air taxi operations along the tarmac. "Audi Helicopters was the first company dedicated to helicopters here," he says. "My father bought his first in 1967—a Bell 206—hence my passion."

That first 206 was joined by another, and then by a Messerschmitt-Bölkow-Blohm MBB-105 twin-turbine ship. But the empire over which Audi now presides is the creation less of those aircraft than of a lightweight alternative from the United States: Frank Robinson's relatively inexpensive piston-powered machines, which Audi introduced in Brazil during the 1980s. The congruence of Robinson's designs and the

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Helipads marked with a "P" are private, and those with an "H" are public. The "3" on this helipad notifies pilots that the structure can support no more than three tons.

rotary-wing infrastructure of São Paulo created a niche that Marco Audi has deftly exploited. About a third of the civil helicopters now operating in Brazil are Robinsons, brokered by Audi.

He discovers markets everywhere he looks. "I believe that Brazil is the number one market in the world for ENG," he says, referring to aircraft rigged for electronic news gathering. Over São Paulo, 14 Robinson R-22s give live traffic reports every day. And in a city where most tall buildings have helipads, the light machines take the place of armored cars, carrying money from bank to bank. One security firm flies nine R-44s, several of which are in the air at any given moment. "People in the branch, when they see the bad guys, they push the alarm," says Audi. "The helicopter is overhead in less than two minutes.

"We brought the concept of LOJAC [a stolen-car recovery system] here," he continues. "When LOJACIL opened in Brazil, we gave them the idea of using helicopters. Sold three helicopters. They're up all day, all night."

Then there's the filthy rich, who have always known that life is better at a thousand feet and a hundred knots. But in São Paulo, vertical thinking is taking place among the merely rich and nearly rich as well. There may be only a handful of people wealthy enough to own and operate a $7 million twin, but there are legions with enough money to consider something less expensive, like an R-44.

To help that thinking along, Audi and a young partner, Allan James Paiotti, have set up an ownership arrangement called Helisolutions, which appears to be feasible only amid the helicopter-oriented culture of Brazil. The cost of the machine is divided among 10 clients, each paying about $40,000 for a share of an R-44 and some fraction of the costs of owning and operating a helicopter. Each helicopter has a satellite transponder linked to the Helisolutions control center, where headquarters can monitor in real time the position, altitude, and velocity of its entire fleet. If an aircraft drifts off the computer-prepared route, it triggers an alarm. In practice, the system lets Audi connect each customer with the nearest helicopter. "You actually have a piece of one specific helicopter, but you have access to a great fleet," Paiotti explains. "All R-44s look exactly alike. All you

Helisolutions' fleet of piston-powered Robinson R-44s awaits a call from participants in a fractional ownership plan.

do is make a call and get a helicopter. It's as if the helicopter is your own."

Fractional helicopter ownership has taken off in Brazil. Since December 1999, Helisolutions has sold 80 shares in R-44s. The company is also prepared should a Robinson shareholder come down with turbine envy. For about $124,000 and a matching bump in associated costs, a customer can move up to Eurocopter's EC-120 Colibri single; $198,000 gets you a piece of an AS-350 B3 Esquilo, also from Eurocopter; and for a mere $1.3 million, you can buy one-fifth of a Bell 430 twin, which seats up to 10 people in a roomy, leather-trimmed cabin.

A different way to pool resources is the Latin American practice called *consórcio*, which is how Helibras, a division of Eurocopter Brazil, is hoping to market its AS-350, a single-turbine helicopter that starts at $1.2 million. At the Helibras com-

"PEOPLE IN THE BRANCH, WHEN THEY SEE THE BAD GUYS, THEY PUSH THE ALARM. THE HELICOPTER IS OVERHEAD IN LESS THAN TWO MINUTES."

Helicopter travel is often the quickest way for law enforcement to respond to calls in sprawling São Paulo.

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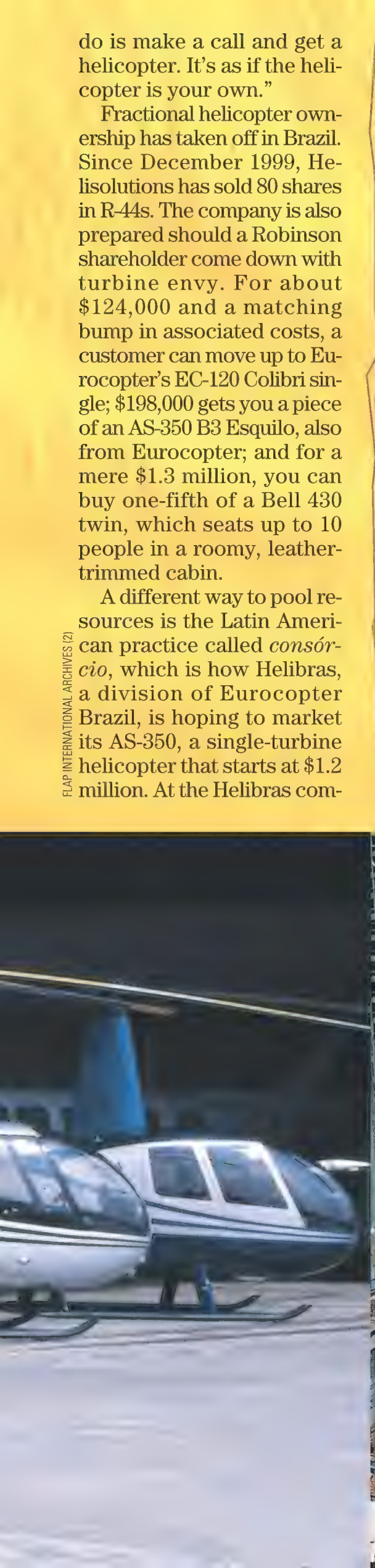

Privately run Helicentro maintains and fuels the turbine-powered craft (such as the Agusta A109C in foreground) of some of São Paulo's wealthiest residents.

TUCA REINES

plex at São Paulo's Campo de Marte airport, Helibras commercial director Fabrice Cagnat explains how the *consórcio* works: "You join a group of people who want to buy something, an apartment, a car, whatever." In buying an automobile, for example, 10 people get together and each pays one-tenth of the cost of the car each month. "At the end of one month, you own one car. The lottery within the group gives the car to one owner. In 10 months you buy 10 cars." It's a welcome alternative to taking out a loan; in Brazil, interest rates can reach 17 percent per month.

Cagnat talks helicopters with the confidence of someone holding four kings. Eurocopter Brazil set up a factory under the Helibras name at São Jose dos Campos, some 60 miles up the Rio highway from São Paulo, for the assembly of the popular AS-350. Today, Eurocopter holds about half the Brazilian military market for rotary-wing machines. "In the civil market our share is not as extraordinary as we'd like," says Cagnat. "But our sales share is [still] quite good. We do not consider Robinson as a competition. After [customers] get used to rotary wing, they go to Eurocopters. One customer bought a piston, now wants to get a turbine."

Cagnat believes that demand is open-ended: "Brazil has about 160 million people. One percent of them can afford helicopters. That's 1.6 million potential users." With Heliplano, Helibras' *consórcio*, that number is even greater. But don't try this at home. Like Audi's Helisolutions, Heliplano may be possible only in a helicopter-hungry country like Brazil.

In São Paulo, no matter how you buy your helicopter, once you're an owner, you'll probably spend some time at Helicentro. A manicured island of rotary-wing aviation, it caters to its wealthy neighborhood, Morumbi, and others like it. "Maybe we found a niche," says Helicentro owner Ricardo Zuccolo. "We're the only company with a facility outside the airport. We have more than a hundred customers."

The 35 or so helicopters at Helicentro are turbine-powered—Zuccolo's Shell dealership doesn't even sell fuel for piston engines. "Easier for our technicians to do one kind of engine," says Zuccolo. "With turbines, maintenance is cheaper, more profit."

A walk through the Helicentro hangar is a walk through the current state of the helicopter art, with several dozen Bells, Agustas, Eurocopters, and Sikorskys. The 28-year-old son of a local businessman owns and flies an MD-250 that looks like a black widow spider—his million-dollar flying Ferrari. But helicopter ownership in São Paulo doesn't mean you have to learn to fly one. Most owners hire a pilot.

Flying a helicopter is one of the good jobs in Brazil. An entry-level commercial R-44 pilot might earn 4,000 reals—about $1,600—a month, plus benefits. Most commercial helicopter pilots earn about twice that, and those flying the larger ships may bring in $80,000 a year. There are always good slots waiting for high-time helicopter captains, who are hard to find and harder to keep. This standing opportunity has drawn legions of aspiring pilots to about a dozen flight schools in São Paulo, each of which churns out perhaps 50 pilots a year. Most budding pilots become instructors as soon as they earn a rating; then, when they've built sufficient time, they head for what everyone calls Offshore.

Offshore is shorthand for a host of oil fields—in the Amazon delta and on the

north coast in the Atlantic Ocean. Offshore is where pilots deepen their experience, flying in extreme conditions rarely encountered over the mainland. After working Offshore, they graduate to flying for a corporation or private owner.

Marco Infante, now the captain of a Bell 407 kept at Congonhas Airport, falls somewhere between the new kids learning at Campo de Marte and the old eagles. He got his licenses in the United States, in Van Nuys, California. When he came home, he found work as a Bell 407 copilot. "A lot of jobs after that," he says. "Some time Offshore, always as a copilot. Then I started flying the jungle. Then I came to São Paulo, to the market for VIP aircraft."

But Infante's job isn't with a corporation. "The kind of work that I do is for the owner," he says. "A few flights during weekdays, but mostly on weekends. They own the 407. The whole family is flying now. Saturday morning I flew them to the beach. Sunday I'll pick them up."

IN A CULTURE OF VERTICAL FLIGHT, A HELICOPTER MISHAP IS FRONT-PAGE NEWS. PEOPLE STILL TALK ABOUT THE WOMAN WHO WALKED INTO THE TAIL ROTOR.

His friend and colleague, Luiz Cintra, also learned to fly in the United States, then worked as an instructor for a couple of years in São Paulo before moving on to flying traffic helicopters, air taxis, and, for a corporate job in which he flew VIPs, a JetRanger. Now he flies the Agusta 109 for a private owner. "It's fun," he says, noting that landing on highrise rooftops "is no big deal. We always land to a point. It doesn't matter where the point is. But there is no ground effect [the cushion of air helicopters create near the ground] on rooftops. When the client wants to carry a lot of stuff, you have to know how to say no."

The aircraft are mainly a convenience, he believes, a way of saving time on recreational travel. In the course of these jaunts, pilots can become something like a member of the family. "The way your job is, you have a very close relationship with the owner, the family," he says.

In a culture of vertical flight, a helicopter mishap is front-page news. People still talk about the woman who walked into a tail rotor a few years ago and was killed, along with the companion who tried to rescue her. Last July 27, an Agusta 109 crashed during a night approach to Maresias, a popular resort and surfing beach. The aircraft belonged to the Pao de Acucar supermarket chain, owned by Abilio Diniz. Aboard were a pilot and copilot; the owner's eldest son, triathlete Joao Paulo Diniz; and fashion model Fernanda Vogel. All four survived the crash and tried to swim the two miles to the beach through rough seas. Only two reached shore: Diniz and copilot Luiz Cintra.

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With helipad construction flourishing (foreground), the number of helipads in São Paolo is expected to grow in the next few years from 250 to 400.

Barring such high-profile crashes, helicopter ownership is a closely kept secret in São Paulo. The wealthy may stick a helipad between the pool and tennis court, but they don't want to advertise that they are rich enough to own a helicopter. When you bring out the camera, you're told: No tail numbers please. As for talking directly with an owner, forget it.

Northerners tend to think of Brazil as a huge country with only two big cities, São Paulo to the south, Rio de Janeiro 300 miles to the northeast, with scads of villages scattered everywhere else. In fact, all 27 state capitals are huge; the state of São Paulo, in which the city of the same name is located, has several cities with populations of more than a million. Dire poverty exists, to be sure, but there is also great wealth—enough to acquire a helicopter, hire a pilot, and take the family to the beach.

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All that REMAINS

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OLD AIRCRAFT CRASH SCENES *are* LITTERED *with* STORY FRAGMENTS.

Amateur wreck investigator Trey Brandt holds a propeller blade from a KC-97G that crashed into Arizona's Gray Mountain in 1957. (Above: a KC-97 in a happier scenario.) Standing in the background is Brandt's friend Jim Fusco.

"Jeez," someone says. "You'd think they could've found a better place to crash."

The words would sound callous anyplace else, especially when you consider that the place in question is one where 16 men were killed in the line of duty. But for the last half an hour we have been crawling up a steep ravine of tottering sandstone boulders, and the effort is proving a little more than some of our party had signed on for.

Finally, as we approach a bend in what can only generously be called a trail, Trey Brandt, our guide on this clear winter morning, draws our attention to a Volkswagen-size metallic shape glinting below.

"Look at that thing," someone says.

"Amazing," says another.

Several of us clamber down for a closer look, quickly gaining an appreciation of both the size and the complexity of the R-4360, the largest radial aircraft engine ever mass-produced. The dry high-desert air has left the parts so free of corrosion that they look as if they could have been cast last week. With cylinders snapped off and valves and connecting rods exposed for easy scrutiny, the Pratt & Whitney serves as the ultimate exploded diagram.

"There's a lot more further up," Brandt assures us.

Today marks Brandt's sixth march up Gray Mountain, a sheer edifice of boulder and brush in northern Arizona where, in 1957, an Air Force KC-97G Stratofreighter refueling tanker sent out to map low-altitude training routes made a wrong turn in bad weather and met a violent end. Still, Brandt, a quiet, self-effacing 32-year-old Phoenix stockbroker, shows no signs of tiring of the trek.

Brandt is a wreck chaser, one of a small number of enthusiasts whose passions lie among the scattered fittings and twisted metal at the places where military aircraft have crashed. They learn of the sites by trading rumors and poring

BY HOWARD JAMES STANSFIELD
PHOTOGRAPHS BY DAN COOGAN

HOWARD JAMES STANSFIELD

An Allison J35 jet engine lies at a site south of Phoenix where a Republic F-84 Thunderjet fighter came to rest after a Korean War-era training accident.

over old accident reports. Some chasers specialize: In Southern California, Tony Moore and Pete Merlin have concentrated on 1950s experimental Air Force craft (see "The X-Hunters," Feb./Mar. 1995). A few are pilots, but most aren't, and almost none has formal archaeological training.

Brandt sees himself as an amateur historian, and the sites offer him a chance to commune with the past in a direct way—to stand at some desolate scene with an old accident-report photo showing men and equipment swarming about a shattered, smoking hulk, then line it up with the nearby landmarks until past and present merge.

For Brandt, locating the wreck is often just the beginning. He has gone on to track down and contact long-retired pilots and crewmen, leading some to the places where their craft came to rest. "I guess I do it because that's where you hear the kinds of things that never make it into the reports," Brandt says. "Guys'll say 'Yeah, I bailed out and then my chute collapsed' or 'I was getting blown toward the mountains, but then I started getting blown the other way and things worked out all right.' That's the kind of thing that makes it really interesting for me."

In the decade he has pursued the hobby, Brandt has visited close to 100 sites and contacted at least that many pilots, crew members, and deceased crew members' families. He has also led next of kin to sites so they could pay tribute to lost fathers or grandfathers.

Craig Fuller, on the other hand, has yet to contact anyone even remotely associated with any of the wrecks he has explored. "I'm pretty introverted in that regard," he says. "I'm not a good cold caller." But in the subspecies *Wreck chaser americanus*, Fuller, a bookish 32-year-old university flight instructor, is an alpha male. He has been to some 200 wreck sites. In his home, near Phoenix, cowlings, control stick grips, throttle quadrants, and instrument faces all vie for shelf space with tomes about warbirds. On one wall hang neat rows of data plates—small pieces of metal once attached to airplanes, each stamped with a serial number, aircraft type, and contract number. A data plate is the wreck chaser equivalent of an autographed home-run ball.

Fuller has converted a bedroom into a home office, where large metal cabinets sit crammed with spools of microfilm containing most U.S. military air accident reports from 1918 through 1955. Fuller began buying the archive when it was declassified in 1996.

Among the vocation's more ardent devotees, a certain collegiality prevails, and a certain amount of information is shared. Fuller, for example, sells copies of his accident reports; in a given month, he may sell 20 to 25. He also conducts at least two "workshops" a month, leading fellow enthusiasts on searches for Arizona wrecks.

But there is also some friendly competition—and some guardedness. Recently Brandt got a call from a woman who said she was writing a book on wrecks and wanted the exact coordinates for the Gray Mountain site. Brandt had discovered those only by investing a good deal of time and money, so he declined to provide them to the caller. "She was not happy," he says.

One evening, a group of us sets out on one of Fuller's workshops, piling into trucks for a three-hour drive from Fuller's home to the southeastern Arizona town of Wilcox. There, we spend the night at the home of Jim Fusco, a wreck chaser and friend of Fuller's and Brandt's. Early the next morning, Fuller and Fusco lead us to a site where in 1943 a B-24 plowed into a mountain. According to the Army Air Forces accident report, the bomber's rookie crew got lost after departing Tucson on a night training mission.

Our trip illustrates an axiom of wreck chasing: The more inaccessible the site,

Some recently discovered remnants of the Gray Mountain KC-97G, left to right: (1) an emergency ration kit, (2) the kit's contents—coffee and tea packets and a vial with water purification tablets, (3) 8-mm home movie film, which turned out to still have a few intriguing images. (4) Fusco inspects part of a parachute harness.

the better the payoff. This site took us almost three hours to reach on foot, but we were rewarded by the sight of the World War II aircraft's intact wings, complete with landing gear still tucked inside the wells, and aluminum skin that gleamed as if it had been riveted into place yesterday.

Fuller says his idea of a "dream site" would be one he stumbled across without prior knowledge, leaving him to "solve the riddle." It probably would not take him long. If the wreck site is that of, say, a World War II-era Vultee BT-13 Valiant, he will tell you that the airplane likely spun in, because that type had among the most unforgiving spin characteristics of any trainer ever produced. Using one of the thick parts catalogs he carries with him, he can translate a tiny inspector's stamp on a shard of metal into a precise part identification, right down to the plant where the part was manufactured.

G. Pat Macha, a chaser from California, shares Fuller's fantasy: "The thing that gets me," he says, "is the thought that there could still be something under the sun that no one has ever seen before." Macha, a soon-to-retire Los Angeles high school history teacher who has written several books on the subject and who many consider the dean of wreck chasers, began hunting wrecks throughout California in the early 1960s. In the years since, he has visited more than 300 sites.

Master of disasters Craig Fuller minored in accident investigation in college. Today, his home office houses a vast archive of accident literature.

Macha is occasionally called upon to help solve an aviation mystery—identifying debris stumbled upon by hikers and forest rangers, for instance. Two years ago, he received a call that topped them all. The caller was Ken Whitall-Scherfee, a Sacramento attorney; his wife, Laura, is the great-niece of Gertrude Tompkins Silver, who had flown with the Women Airforce Service Pilots, the only group of women to fly U.S. military aircraft during World War II. One evening in 1944, Silver took off in a factory-new P-51 Mustang from Mines Field (now Los Angeles International Airport), detailed to ferry the aircraft to New Jersey for shipment overseas. Her first stop was Palm Springs, and she never made it. Silver became the only WASP to go missing. Whitall-Scherfee asked if Macha was interested in helping solve the riddle.

Macha was. He had long considered Silver's disappearance one of the more intriguing aviation mysteries of the Second World War. After studying the official Army Air Forces report, Macha theorized that Silver had become disoriented shortly after takeoff when she flew into a fog bank that had rolled in over Santa Monica Bay, just a mile and a half from the end of the runway at Mines. Last September, Macha and a group of volunteers began planning a survey of the bay's bottom with sonar scanners they'd been able to borrow. Unfortunately, technical and logistical problems (after the September 11 attacks, "we didn't want to have to explain to the Coast Guard what we were doing under the flight path to LAX," he says) forced the team to halt its efforts. Macha hopes to try the survey again sometime this year.

Trey Brandt has also worked with family members to help them find out what exactly happened to their loved ones. He recalls a recent example: Dur-

When the KC-97G crashed, one of its 3,400-pound Pratt & Witney engines was flung far down the mountain from the main impact site.

ing his first trip to the Stratofreighter crash site on Gray Mountain last year, Brandt spotted a wadded-up blue airman's jacket wedged under a boulder. In one pocket he found a medal of St. Anthony, patron saint of, among other things, shipwrecks and seekers of lost items. In another pocket he found a set of dog tags belonging to one of the Stratofreighter's crew members. The jacket, Brandt guesses, had been left there by a member of the Air Force recovery team, who had pocketed the dog tags while scouring the site. Brandt continued to search, and ended up finding the dog tags of four other crew members, along with personal effects, including a watch stopped at 8:54 a.m.—a little more than 30 minutes after the airplane made its last position report.

Back home, Brandt began doing what he does so well, eventually tracking down survivors of three of the five crewmen and returning the dog tags. One of the survivors was Doris Dees, widow of the Stratofreighter's copilot, Charles Darwin Dees. Brandt contacted her at her North Carolina home in June 2001. "I thought it was some sort of scam," she recalls. "I kept waiting for him to ask me to send him money."

Once convinced of Brandt's sincerity, Doris told him about her life after losing Charles. She had moved back to the small town she had grown up in and where she had met Charles at the high school for black students. She went back to teaching, raised her son and daughter, became a grandmother, retired. She never remarried; Charles was her one true love.

In all those years, the question of what had really happened to Charles hovered over her like the old photo of him she kept on her mantel. The Air Force had never produced a body, instead interring the crew's remains in a single casket at Arlington National Cemetery, outside Washington, D.C. Over the years, Doris often wondered whether Charles might not still be alive somewhere. What if he had bailed out and been injured, perhaps suffering amnesia, wandering the country like some real-life Manchurian Candidate?

Those questions were finally laid to rest a few days after she spoke with Brandt, when an envelope arrived from Phoenix. Inside were Charles' dog tags. Doris took them out and held them, then hung them from his photo on the mantel. She says she hasn't felt quite the same since. I ask her whether that's a good thing or a bad thing. "Oh, its a good thing," she quickly responds. "Now I know."

Left: At an Arizona site where a B-24 fell to earth, Fusco erected a memorial to honor the crew members, all of whom died.

Considered by many the dean of wreck chasers, G. Pat Macha has visited 300-plus sites. His next goal: a P-51 that may lie in Santa Monica Bay.

HOWARD JAMES STANSFIELD

CHAD SLATTERY

Little stands between most wrecks and oblivion. The Air Force washed its hands of the majority of its crashes when a fire destroyed the titles to all aircraft wrecked before 1961. "After that, the Air Force decided any wreckage sites from before that date would be considered formally abandoned," explains Brad Smith, who heads the Air Force's disposal and donation program, located at Wright-Patterson Air Force Base in Dayton, Ohio. Anyone wanting anything from a pre-'61 wreck needs only the permission of whoever owns the land where the wreck resides. As for post-1961 wrecks, Smith's office reviews salvage requests on a case-by-case basis.

The Navy takes a much more proprietary view of its wrecked craft. "The Navy basically considers all wrecks—both ships and airplanes—to be its property forever," says Wendy Coble, a Naval archaeologist in Washington, D.C. The Navy takes a dim view of salvagers, she says, because wreck sites often are the last resting places for their crews. (Most everyone who has visited a fair share of sites has come across human remains.) The Navy's policy is also based on the danger of unexploded ordnance. Then there's the fact that the aircraft were purchased with taxpayer money: "They should belong to everyone," Coble says. Some salvagers disagree with the "keep off" policy, pointing out that the Navy itself does not salvage many of its wrecks and thus risks losing valuable artifacts to neglect and exposure (see "Whose Planes Are They Anyway?" Oct./Nov. 1998).

Even though people may have died at them, most wreck sites aren't considered significant historically, so they are offered no protection under the National Historical Register. The only recognition such sites will ever receive comes from the wreck chasers themselves, some of whom have erected simple memorials. Jim Fusco put one up last year at a site in southeastern Arizona where in 1943 a B-24 exploded in mid-air while being ferried from Texas to Arizona. The Army Air Forces removed the large pieces of the bomber, but small bits are still scattered over the area like shells on a beach. In the middle of the debris field stands a simple aluminum cross listing the aircraft

type, the date of the explosion, and the names of the four crew members who died in it. The cross is hidden by thick creosote and ocotillo and set back from the nearby freeway. I ask Fusco why he installed a monument that so few will ever see. "I just felt like I needed to give something back," he says.

But wreck chasers can also pose a threat to the sites. At Gray Mountain, I sit down on one of the warm rocks to enjoy the remarkable view the clean, dry air affords: Our trucks appear as glinting specks far below. It's a view that invites reflection—or would invite reflection, were it not for an obnoxious clanging coming from somewhere above me. I swivel around and see one of the members of our party—a retired gentleman, a friend of a friend of Brandt's—hammering at something on one of the engines with a rock. After several minutes, he finally comes away with his prize: the data plate from the engine's fuel injection unit.

The sight of a grown man smashing away at a piece of aviation history with such troglodytic abandon galls me, but then who am I to judge? Beside my computer at home sits a .50-caliber shell casing I pocketed at the B-24 mountain crash site, a theft that makes me as guilty as Mr. Dataplate.

Larger-scale threats have also endangered the sites. At one time, the warbird restoration industry relied heavily on wrecks for cheap parts, though by now most of the easily scavenged bits have disappeared. Warbird dealers have even taken entire wrecks, the big prize being the data plate. A dealer can construct an entire airplane of cannibalized or remanufactured parts, slap on the data plate, and then market the ersatz result as a genuine warbird.

Then there are the scrap metal dealers. As we make our way up the Gray Mountain ravine, we pass several rusted, concrete-lined 55-gallon drums—makeshift smelters used by aluminum scavengers who hit the site during the 1960s. All of the Stratofreighter's major airframe components—the fuselage, wings, and tail—are now gone, cooked down into ingots that were hauled out by pack mules.

Nonetheless, the Gray Mountain site still holds surprises. The day I visit, we find emergency food kits with intact packets of bubble gum and dehydrated coffee and tea, plus bars of toffee melted into a molten mass. We also come across .22 Stinger rounds from the gun in the airplane's survival kit. But it is Trey Brandt who makes the supreme find: a cartridge from an 8-mm movie camera. Later, he will rush the cartridge to a film lab in Canada that specializes in such things. Amazingly, a few faint, sepia-tinted frames turn out: a dour, corn-fed-looking woman standing in her kitchen in a plaid house dress, arms akimbo, in an aspect Grant Wood would have admired; the same woman with a small boy standing in front of her. It's impossible to tell who they are, their faces having been made unreadable by poor lighting and the film's condition. Perhaps she is the mother of one of the crewmen, or the wife. Perhaps he is a son who is still alive somewhere.

For a wreck chaser, it's a great find. But it's not one that would interest an academic historian. This site, after all, isn't Normandy or Buchenwald. It's just a junk-strewn heap of rocks in the middle of nowhere, a place where, on a fall day in 1957, an enormous silver airplane came hurtling out of the clouds with the terrible force of eighty tons pulled by fourteen thousand horses, toward the spot where we now stand, on a mountain that was not supposed to have been there.

I can only hope they never saw it coming.

Fuller's greatest hits: A wall in his home displays the aircraft data plates and placards he's found at various crash sites over the years.


U.S. AIR FORCE
60756

SKY HIGH

My climb to the top in the F-104. by George J. Marrett

THE LOCKHEED F-104 STARFIGHTER LOOKED MORE LIKE A ROCKET THAN AN AIRPLANE. OUT IN FRONT WAS A SHARPLY POINTED NOSE WITH A LONG PITOT TUBE. THE AIRPLANE'S STRAIGHT, STUBBY WINGS WERE CANTED DOWNWARD, AND THEY WERE SO THIN AND SMALL, LIKE FINS, THAT YOU WONDERED HOW IT COULD FLY. LOCKHEED PRESS RELEASES EVEN DESCRIBED THE AIRPLANE AS "THE MISSILE WITH A MAN IN IT." FOR PILOTS, ITS TINY CROSS-SECTION MADE IT THE KIND OF AIRCRAFT YOU PUT ON LIKE A GLOVE. THE COCKPIT WAS SMALL BUT COMFORTABLE, AND THE PILOT SAT RECLINED WITH LEGS EXTENDED, THE WAY YOU SIT IN A SPORTS CAR.

Early versions were designed with an ejection seat that fired downward, and to prevent injuries the pilot wore metal spurs attached to his flight boots, cowboy style. The spurs were connected to cables that would automatically pull his feet against the ejection seat during an ejection. Later, the seat was redesigned to fire upward, but the spurs stayed. Most pilots put their spurs on just before they boarded and took them off immediately after deplaning; others wore them around to show off. When I was a second lieutenant attending flying school, I saw an Air Force colonel wearing an orange flying suit and a dress military hat with "scrambled eggs" on the visor. His spurs were clinking and clanking as he walked. Then and there I knew I wanted to fly the Starfighter.

I got my chance in December 1963, when I was selected to attend the U.S. Air Force Test Pilot School at Edwards Air Force Base in California. At the time, the grand old man of supersonic flight, Colonel Charles E. "Chuck" Yeager, was the commandant of the school, and he was guiding the Air Force toward the new frontier of spaceflight.

Our class had 10 Air Force pilots, two Navy pilots, two NASA pilots, and one pilot each from Canada and the Netherlands. We all wanted to be part of the Space Age even though our very presence here put us in competition with NASA. The Air Force had initiated its own manned space program with the Boeing X-20 Dyna-Soar, a single-seat space vehicle scheduled to make its first flight in 1966, just three years away.

All X-20 pilots would be graduates of Yeager's school and actually fly their

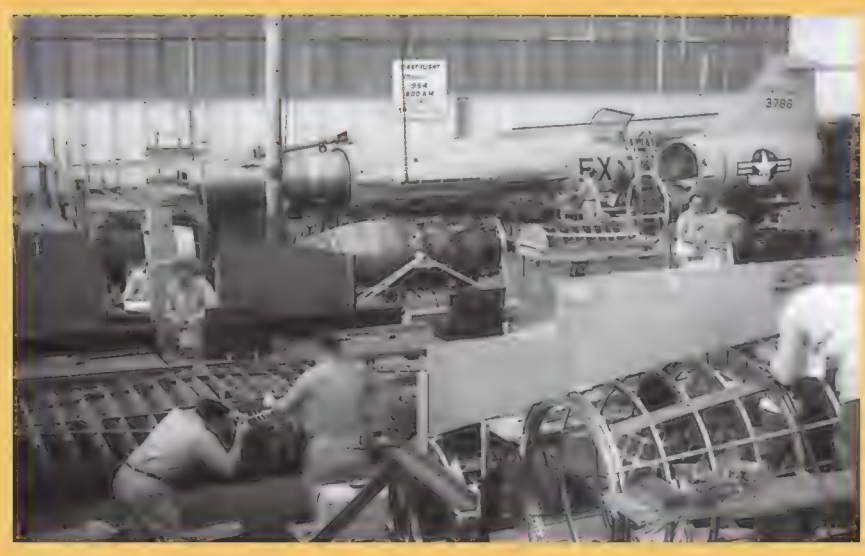
Zoom climbs in the rocket-boosted NF-104 could top out at 120,000 feet in zero gravity (left). The author (above, in 1965) hit 80,000 in a stock model.

COURTESY GEORGE J. MARRETT (2)

How the F-104 Starfighter Was Born

During the Korean War, the U.S. Air Force became concerned about the advantage the Soviet MiG-15 had over the Lockheed F-80 Shooting Star and the North American F-86 Sabrejet. The MiGs were lighter and had a greater thrust-to-weight ratio, so they could climb faster and reach higher altitudes than the U.S. fighters. The Air Force was downing 12 aircraft for every one it lost, but that was believed to be due to superior pilot proficiency. The Air Force wanted a jet fighter that would exceed the MiG's performance in every category.

Chief designers Kelly Johnson of Lockheed and Lee Atwood of North American Aviation were invited to visit South Korea to talk with Air Force combat pilots. The two men learned that the pilots wanted greater speed, power, and maneuverability.



LOCKHEED MARTIN (2)

At Lockheed's Burbank plant, workers assemble the minimum airplane around the maximum engine.

New aircraft were already in design or under construction: North American's F-100 Super Sabre and McDonnell's F-101 Voodoo, both of which used the Pratt & Whitney J-57 engine. Johnson decided he had to use a more advanced engine. He considered several but chose the General Electric J-79. It was unproven and using it carried some risk, but it had higher thrust than the J-57; if the pilots wanted speed, Johnson would give it to them.

The revolutionary new jet would have Mach 2 speed, be unequaled in time to climb, operate at over 60,000 feet, and combine the attributes pilots wanted. Johnson had to keep airframe weight and drag low. A very thin, straight wing offered excellent performance at high speed. A delta wing has less drag per square foot at transonic speed, but its lift during takeoff and landing is reduced. To compensate, designers had to double its area, so the total drag of a delta wing was greater. The high speed regime, combined with a high thrust-to-weight ratio, pointed to a low-aspect-ratio (in a word, stubby) wing, because it would produce less drag. Johnson proposed a wing so thin and sharp—the leading edge had a radius of only 0.0016 inch—that the edges had to have covers to prevent nicks and keep people from cutting themselves. Ice would not build up on the edge, so there was no need for heavy de-icing equipment. The wings were located nearly two-thirds of the way back on the fuselage, and the tips were squared off, permitting the installation of jettisonable fuel tanks or the Starfighter's primary armament, a pair of AIM-9 Sidewinder heat-seeking air-to-air missiles.

The vertical tail extended about as high as the wing extended sideways, so the vertical tail would contribute a large dihedral effect; dihedral tended to restore the fighter to straight-and-level flight. To moderate the overall dihedral, the wings had 10 degrees of negative dihedral. They drooped a little.

The Starfighter had a "flying tail"—the entire horizontal surface moved—placed high above the engine exhaust, so it could be made of aluminum instead of heat-resistant but heavier stainless steel. Even at Mach 1.5 the flying tail was very effective, allowing the pilot to pull five Gs in a turn at 35,000 feet.

Johnson's fighter never got a chance to tangle with any MiGs, but if it had, it would have left them in its contrails.

Lockheed designer Kelly Johnson got input from combat pilots in Korea.

spacecraft from liftoff to an unpowered landing on Edwards' Rogers Dry Lake. NASA astronauts, on the other hand, returned to Earth in a capsule suspended from a parachute and landed in the ocean.

Yeager was instrumental in changing the curriculum of the test pilot school to include spaceflight training. The name of the school was also changed to Aerospace Research Pilot School, though it was commonly referred to as Yeager's Charm School. He still had the golden touch: Yeager seemed to have a credit card enabling him to tap into the Air Force budget, and there seemed to be no limit to what he could spend. His motto appeared to be "Follow me. I will put the Air Force in space."

To give his students a real taste of space, Yeager contracted with Lockheed to modify three production F-104s for high-altitude flight. Designated NF-104s, they were inexpensive trainers that would expose students to altitudes above 100,000 feet. Like the X-15, the NF-104s had small directional thrusters in the nose and wingtips for attitude control up where normal controls had no effect.

Each NF-104 was equipped with a Rocketdyne liquid-fuel rocket engine that used JP-4 fuel and hydrogen peroxide as an oxidizer to produce 6,000 pounds of thrust. With the reaction control system, a student could control the NF-104 on a zero-G trajectory through the thin atmosphere at the edge of space for about 80 seconds. The pilot wore a pressure suit; with-

out engine power at that altitude there was no cockpit pressurization.

It was widely understood that whoever first pushed the NF-104 to its maximum performance was certain to set a world record for altitude achieved by an aircraft taking off under its own power. In 1961 the Soviets had set a record of 113,890 feet with the E-66A, a rocket-powered variant of the MiG-21 fighter. Some U.S. X-planes had flown higher, but they had to be carried aloft by a Boeing B-52 (see "Mother," June/July 2001).

In 1963, Lockheed began shakedown flights on the NF-104 with company test pilot Jack Woodman. After a few months the program was turned over to Major Robert W. "Smitty" Smith at the Air Force Flight Test Center (AFFTC), flying out of the Fighter Branch of Test Operations. A year later, when I was assigned to the fighter branch, I did a little off-the-record dogfighting against Smitty. By disabling the safety system that prevented loss of control at high angles of attack and high Gs, he could fly the F-104 near its aerodynamic limits. You couldn't beat Smitty in an F-104.

To reach maximum altitude, the pilot accelerated the NF-104 at full power to maximum speed, then pulled up into a "zoom climb." In a zoom, the more energy you could build up during acceleration—and the more precisely you could maintain the optimal climb angle—the higher the airplane would climb when it coasted to the top of the zoom. Smitty reached 120,800 feet on one zoom—not an official world record because it was a test flight and the official monitors were not in place. Optimum climb angle for the aircraft turned out to be between 65 and 70 degrees, which, added to a 14-degree seat cant and a five-degree angle of attack, left the pilot reclined at an angle of about 85 degrees. You couldn't see the ground from that position, so all zoom maneuvers were made on instruments. On one flight, Smitty tried an angle of 85 degrees, but he lost control and tumbled, going over the top upside down. The aircraft entered a spin but he recovered. Smitty was fearless.

Yeager had taken the NF-104 up three times to get a feel for it, and on December 10, 1963, he was scheduled to fly two zoom flights in preparation for an all-out record attempt the next day. During the morning flight he reached 108,700 feet, but Yeager felt the Starfighter could be taken much higher.

EDWARDS HISTORY OFFICE

Six over 15: In thousands of pounds, that's the thrust of the NF-104's liquid-fuel Rocketdyne AR engine and the General Electric J-79 beneath it.

On the afternoon flight, Yeager's test profile called for him to accelerate to Mach 1.7 at 37,000 feet, light the rocket engine to accelerate to Mach 2.2 at 40,000 feet, and then climb at 70 degrees. As the aircraft passed through 70,000 feet, ground control informed Yeager that he had less than the desired angle of climb. He applied the reaction controls to get back on the flight path, a technique he had used before. But on this flight he was at a lower altitude (101,595 feet) and the reaction controls were not yet effective. There was a higher dynamic pressure on the control surfaces, meaning the horizontal tail would have been more effective. Then, when he attempted to lower the nose at the peak of his climb, he found that neither the aerodynamic controls nor the reaction controls could reduce the angle of attack enough to prevent a spin. Soon he was gyrating in all directions, and nothing would stop it. A mile above the desert and falling like a manhole cover, he ejected.

As his parachute opened, he was struck in the face by the base of his rocket seat. His helmet's visor broke

LOCKHEED MARTIN

The air inlet design was a coyly shrouded secret at a 1956 press preview.

and burning residue from the rocket entered the helmet. Pure oxygen for breathing was flowing to the helmet, igniting a flame that started to fry his neck and face. As he descended, Yeager removed a glove and used his bare hand to try to put out the fire around his nose and mouth, charring two fingers and a thumb. The aircraft hit the ground in a flat attitude, and Yeager landed a short distance from the wreckage. Within a few minutes a helicopter and flight surgeon arrived. Yeager had second-degree burns on the left side of his face and neck and on his left hand, and a cut on one eyelid.

The loss of an NF-104 was not the only bad news that day: Secretary of Defense Robert S. McNamara announced the cancellation of the X-20. The Air Force lost a manned space program, Yeager was injured and wrapped in bandages, and the Air Force had put a hold on his spending.

The two surviving NF-104s were grounded pending an investigation, so I wouldn't get to fly one. But the standard Starfighter was still the hottest airplane in the Air Force inventory, and I wanted to get into it. As a new student, I got my first flight in the back seat of an F-104 with an instructor, Major Frank E. Liethen, as he conducted a functional check flight, or FCF. Regulations called for an FCF any time major maintenance had been performed. The FCF pilot would fly the repaired aircraft at the limits of its envelope to determine that it was safe for student pilots to fly. Only the most experienced pilots were asked to fly these potentially hazardous flights.

Liethen had been the outstanding student in his class at test pilot school. After a year as a project test pilot at Nellis Air Force Base in Nevada, he returned to Edwards to attend the new space school. After graduation, he became an instructor in the school. He applied to become a NASA astronaut, but he was turned down—too tall. Just as he graduated from space school, the Dyna-Soar program was canceled. His only chance for a spaceflight was the Air Force program called the Manned Orbiting Laboratory, or MOL. Unfortunately, the MOL (canceled in June 1969; see "First Up?" Aug./Sept. 2000.) was on the drawing board at the time, and crew selection was years away.

Before attending the school, I became proficient in flying FCFs in the McDonnell F-101B Voodoo at Hamilton Air Force Base in California. The F-101B and F-104 were both designed in the 1950s as supersonic interceptors. The F-101B was a twin-engine, two-seat aircraft with a radar intercept officer. The F-104 had a pilot, one General Electric J-79 jet engine with afterburner, and a short-range air-to-air radar. It could fire a heat-seeking AIM-9 Sidewinder missile. Both had high wing loading (total weight carried per square foot of wing area), a T-tail, and pitch-up characteristics (see "Now Departing: T-Tails and Other Killers," p. 70). Both also had electronic systems to prevent a pilot from entering the pitch-up region.

The F-101 had a horn that sounded in the pilot's helmet as it neared the pitch-up boundary. If the pilot continued to fly the F-101 to an even greater angle of attack or G-force, a mechanical pusher moved the control stick forward. This very complex system required the FCF pilot to adjust the boundaries during flight. The F-104's instrument panel had an angle-of-attack gauge. To warn the pilot that he was approaching pitch-up, a needle would move into a red area on the gauge. If the pilot continued to increase angle of attack or G-force, a stick shaker system caused the control stick to shake in the pilot's hand and emitted a sound similar to a rattlesnake's.

The Starfighter could be a handful

and had a terrible safety record; many pilots had been killed flying it. Only a few years earlier, Iven Kincheloe, who had set a world altitude record in the Bell X-2, was killed in a Starfighter when the engine failed just after takeoff. So as Liethen performed maneuvers in the F-104, tickling the pitch-up boundary, I held the control stick ever so lightly in my hand. He talked on the intercom as he flew, but I watched him like a hawk.

As a student, my zoom flight would be the high point of the 12-month course and my last flight. I'd take the F-104 (not the rocket-powered NF but a standard -104) to the rarefied atmosphere above 80,000 feet.

On the day of the flight, I was sweating profusely, having spent an hour and a half in a full pressure suit. Wearing the helmet and faceplate was like looking at the world from inside a fishbowl. And the helmet was almost as wide as the canopy. I could move my head only a few inches from side to side before the helmet bumped against the plexiglass.

As I sat cooking in the Mojave Desert sun, I felt confident. I'd logged thousands of hours in Air Force fighters, from the F-86 Sabrejet to the F-101B Voodoo. But I'd never flown a Starfighter to 80,000 feet—"Angels 80," military pilots call it. I'd flown the F-104 often in the previous months to get the feel of it. But you always have little doubts when you're trying something that you've never done before.

If I overcorrected at the top of the zoom, I'd be uncontrollable in seconds. Lieutenant Patrick "Pat" Henry, a Navy pilot in the class just ahead of mine, lost control at the top of the zoom, entered a spin, and eventually ejected. If I were not precise in my planning and control, I'd share his fate. If the engine failed to restart as I was coming down, I'd be committed to a flameout pattern.

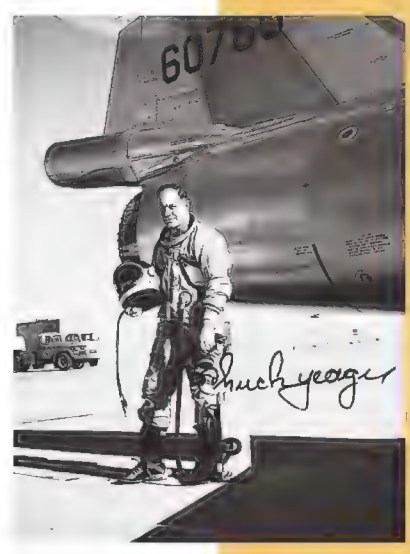
The tower's call interrupted my thoughts. "Zoom 5, you're cleared onto Runway 04 to hold."

Sweat was dripping into my eyes, but it would be cool up where I was headed. A quick glance to my left confirmed that my chase aircraft, an F-104 with the call sign "Zoom Chase," was in position and ready for takeoff. He'd chase me until the pull-up point and then, as I descended through about 30,000 feet, he'd rejoin in formation in order to accompany me through the traffic pattern. He'd check the airplane's exterior, be ready to offer any assistance I might need, and help keep me clear of other airborne traffic, since I'd be focusing most of my attention on the instrument readings.

The J-79 gave its characteristic howl and roar as I eased the throttle full forward and back again to idle.

"Zoom 5, winds are calm, you're cleared for takeoff," the controller said.

No time for other thoughts now. I got a good afterburner light, then pushed the throttle up to maximum afterburner. The acceleration pressed me against my parachute. Control stick aft at 100 knots (115 mph), nose wheel raised at 150, airborne at 175. Landing gear up before 250 knots or I'd rip the gear doors off. Then flaps up. Passing 400 knots, I raised the nose slightly to start my climb and throttled back out of afterburner. Then I started a turn to the east and climbed at 450 knots, waiting for the Mach to build to 0.85.



COURTESY GEORGE J. MARRETT

Chuck Yeager, suited up.

The chase pilot radioed that my Starfighter looked fit to continue. Climbing toward the morning sun, I had only a few seconds to enjoy flying this beautiful aircraft. It was no time to daydream; I had to focus on the test mission. Climbing at 0.85 Mach, I leveled off at 20,000 feet, passing abeam the Three Sisters Dry Lake. It was time to dump cockpit pressurization and inflate my pressure suit. If my pressure suit failed at this low altitude, I would have plenty of time to repressurize the cockpit, abort the mission, and return to Edwards. Slowly the suit inflated. I felt like a fat man in a telephone booth.

On the way to 35,000 feet, I could see Baker's Dry Lake in front of me. The lake bed was about 100 nautical miles east of Edwards, and my turning point for the run back in the supersonic corridor—airspace where speeds over Mach 1 were legal. I made a gradual 180-degree turn to the left, glancing

The Home Front

When I was selected for test pilot school at Edwards Air Force Base, my wife Jan was delighted. But she was concerned about the number of pilots killed during my previous assignment and wondered if test flying would be even more dangerous.

Our second child was expected to be born about two months into my year of test pilot training. We already had a four-year-old son, and Jan did not want her children to grow up without a father. Asked about the risk, I explained that I had had the best training in the world, the test aircraft were maintained to a higher level, and that we flew during the daytime and in clear weather. I wasn't sure how much of that was accurate, but she seemed to accept my explanation.

All but three of the pilots in our class were married, and most had children, so Jan and I weren't the only couple having such discussions. The school may have known this: They planned an open house—an opportunity for the families to visit the school.

On the appointed day, we gathered in the auditorium for Colonel Charles Yeager to make his entrance. When he arrived, he had on rows of ribbons for combat in World War II and for flight test accomplishments. But he also wore a large white bandage around his neck, and his left arm was in a sling. If the premier test pilot in the Air Force was this banged up, it seemed clear to Jan that flight test could be a very dangerous business.

The tour of the hangar held another surprise. Yeager was bandaged up because he'd recently punched out of an NF-104, the wreckage of which was spread out on the hangar floor for an investigation. No piece of his crashed aircraft was larger than a refrigerator, and everything was covered in gray ash. The sight of wreckage was familiar to me, but most civilians, and certainly Jan, had never viewed such a shocking sight.

Jan's concerns would prove to be well founded. Over the next 25 years, 32 test pilots—friends of mine—would be killed in aircraft.

The thrill is gone: Pilotless QF-104s were flown by technicians who experienced speed and altitude only as data.

over my right shoulder to confirm that my chase was still in position.

Rolling out, I pointed the nose toward the town of Tehachapi. Moving the throttle forward, I selected maximum afterburner, easing the control stick forward ever so slightly to unload the one G of level flight and help the Starfighter ease through the transonic zone. The airplane passed Mach 1.0 with no physical sensation. The Mach needle was really climbing fast now: 1.3...1.4...

I tried pushing the throttle harder against the forward stop, hoping to get every last pound of thrust from the engine. Mach 1.7 ...1.8. The F-104 was at its design speed now, and the Mach number was climbing fast. At an indicated airspeed of 675 knots, I started a gradual climb to 38,000 feet. What a tremendous feeling to be going faster and faster. The chase aircraft was miles behind me now. Mach 2.1...2.15... I let the Starfighter accelerate as long as I dared—I wanted every bit of energy I could get. The more speed I built up, the more altitude I'd get over the top.

One last glance at the checklist. I had penciled a reminder for myself when I reached this point: "Check gloves." Just before he started his pull-up, my classmate, Captain Jerry G. Tonini, had the thumb of one of his gloves start to balloon. Fortunately, he caught it in time. Had the glove popped open, he would have lost all suit pressure. If that had happened, he would have lost consciousness in a few seconds and crashed.

LOCKHEED MARTIN (2)

The high tail favored downward ejection until a new seat came along.

The compressor inlet temperature was approaching the limit: 155 degrees Celsius (311 Fahrenheit). A last check on fuel showed just under 1,200 pounds, the minimum before starting the zoom in order to recover with a safe reserve at Edwards. *Go for it*, I thought. *Pull up.* At that moment the image of Yeager wrapped in bandages flashed before my eyes.

I pulled back on the stick gently, entering the climb at a rate of 1 G per second. When the G meter reached 3.5, I kept the pressure constant, and I focused on the attitude indicator in the center of the instrument panel. As I reached 40 degrees of pitch, I began slowly easing off the backstick pressure and held 45 degrees. I monitored the exhaust gas temperature (EGT)—I didn't want to overtemp the engine.

Quickly I glanced at the altimeter. The needles were spinning too fast to read. I'd passed 60,000 feet; EGT was at maximum: 615 degrees Celsius. I began to retard the throttle to hold EGT constant. Passing 67,000 feet, I brought the throttle back into idle cutoff. The engine shut down and started to unwind; at this altitude, if I left it running, even at idle, it would overtemp.

I held the 45-degree climb angle until the angle of attack reached eight degrees, then pushed forward on the stick. Minimum indicated airspeed over the top was 120 knots, the lowest speed at which there was still enough air flowing over the horizontal tail to ensure the tail would be effective. I felt weightlessness coming on. Even though my shoulder harness was firmly tightened and locked on the ground, I felt my pressure suit lift off the ejection seat and my helmet touch the canopy.

Just approaching the peak of the climb, I treated myself to a sweeping view of Earth. Most of the flight so far had been "head in the cockpit, fly the gauges." The sky was very dark blue—almost black. I could see the Pacific Ocean in front of me, although still a hundred miles away. There was smog in the Los Angeles basin down to the left, and at my right I saw the San Francisco Bay area. Sightseeing was over; I had to return to business. I'd topped out at Angels 80. It was so quiet I thought I could hear my heartbeat.

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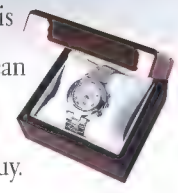

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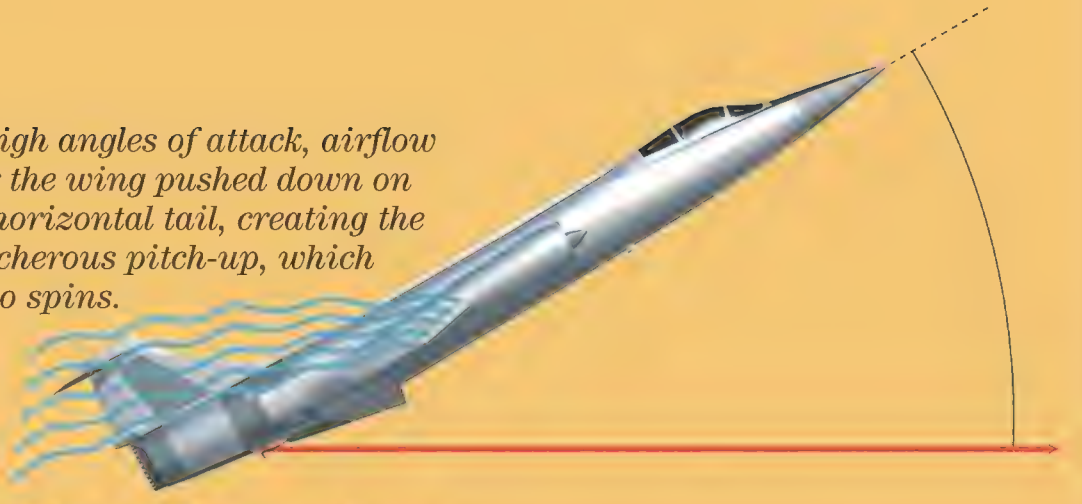


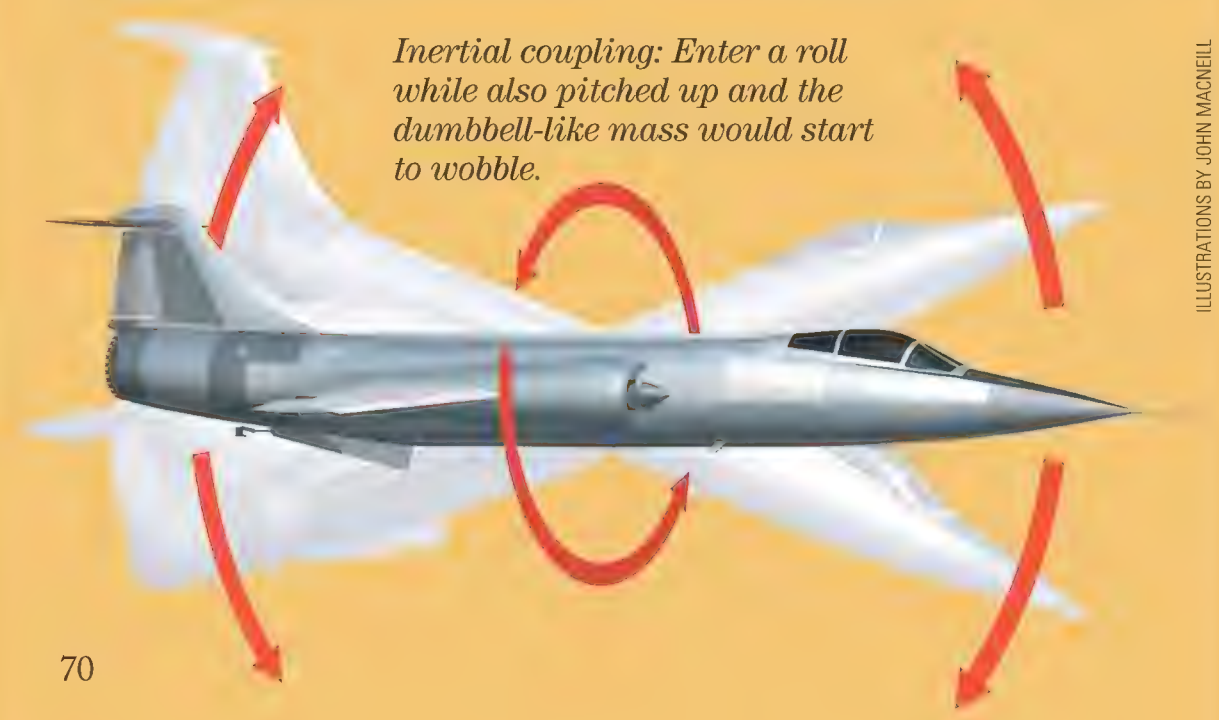
At high angles of attack, airflow over the wing pushed down on the horizontal tail, creating the treacherous pitch-up, which led to spins.

Now Departing: T-Tails and Other Killers

The T-tail on the McDonnell F-101 Voodoo and the Lockheed F-104 Starfighter could create major problems. At high angles of attack, the outer wing sections stalled before the inner wing sections did, and that tended to move the center of lift forward. At the same time, the downwash from the wing began to impinge upon the horizontal tail, changing the angle of airflow over it and reducing its effectiveness. The combined effect caused the aircraft to pitch up.

Most aircraft pitch down when they stall. The nose drops, the aircraft picks up speed, and it returns to controlled flight. In a pitch-up, the angle of attack increases even with the control stick full forward. The aircraft goes out of control and may end up in a spin from which, in both the F-101 and the F-104, it was sometimes impossible to recover. If a pilot could recover by deploying a small drag chute attached to the tail, the ensuing dive recovery could take up to 10,000 feet. A pitch-up below 10,000 feet resulted in an automatic ejection. Pilots were directed never to intentionally pitch up or spin either the F-101 or the F-104; the pilot's flight manual called those prohibited maneuvers.

Lurking in the background was another serious phenomenon. Beginning with the North American F-100 Super Sabre, "Century Series" fighters (those with numerical designations from -100 up) like the F-101 and F-104 were designed with a high concentration of mass along the fuselage. This led to a dynamic characteristic known as inertial coupling, a phenomenon that can best be explained by considering a rapid rolling maneuver. Picture the aircraft at a positive angle of attack. It begins a rapid roll around its longitudinal axis, which is displaced from the direction the aircraft is moving in by the angle of attack. As the high mass along the fuselage begins rotating at an angle to the flight path, it tends to diverge from that path, increasing its displacement in pitch and yaw the longer the roll continues. So in addition to needing a big vertical tail for directional stability, an even larger tail was needed to prevent inertial divergence.



Inertial coupling: Enter a roll while also pitched up and the dumbbell-like mass would start to wobble.

ILLUSTRATIONS BY JOHN MACNEILL

I held zero G until the Starfighter had pitched over into a steep dive. I put the speed brakes out, and airspeed started to build up fast as the light brown Mojave Desert came back into view. I was now diving straight down, with Rogers Dry Lake directly below me. Passing 35,000 feet, I restarted the engine.

The EGT started to rise—I had a good light. With the engine running, I started a turn back to the Edwards runway when I was startled by a silver flash on my faceplate. Then I realized it was a drop of sweat.

I passed my landing reference point at 25,000 feet directly above Edwards' Runway 04, where I had started the flight about a half-hour before. I'd be landing out of the same dead-stick pattern that the X-15 used: 300 knots indicated airspeed and in a 20-degree dive. Base leg altitude was 15,000 feet, but I had flown the pattern many times before and felt quite comfortable. Rolling out on high final at 6,000 feet, I had the 15,000-foot runway directly in front of me. I started the stick coming back for the flare and lowered the landing gear at 250 knots. I checked to ensure the gear was down and locked just before touchdown at 190 knots.

The tires squealed as they burned rubber on the painted white line that crossed the runway at the 10,000-feet-remaining marker. As I lowered the nose gently onto the runway and pulled the drag chute handle, my chase sped past me in a low approach.

With sweat dripping into my eyes, I looked up at the contrail my zoom had etched against the blue desert sky. I had returned safely from the edge of space.

EDWARDS HISTORY OFFICE

One lost, two grounded: The NF-104 went out with the X-20.

"What can a retired pilot do?"

PHOTO: MARK AVINO

"After devoting my life to aviation, I couldn't *just* retire. I remain connected to a field I love through our support of the Museum. Our gift annuities will help inspire future pilots."

— CAPTAIN AND MRS. ELLIOTT

During a visit to the National Air and Space Museum, Captain and Mrs. Elliott stop in front of the DC-3 in the Air Transportation Gallery.

Captain George William Elliott's romance with aviation spanned more than four wonderful decades. He began his career as a flight instructor in the cockpit of a Curtiss P-40. He trained to fly the Northrop P-61C Black Widow, and he retired as a United Airlines captain.

"I had to find a way to stay involved," says Captain Elliott. He and his wife, Virginia, discovered they could arrange a charitable gift annuity to benefit the National Air and Space Museum. "Our gift brought us such joy," adds Virginia Elliott. "George wanted to share his passion for aviation with others." They were so delighted that a year later the Elliotts completed a second annuity.

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10/02

Emergency Exit | William E. Burrows

Give the U.S. space program a mission that means something: saving the species.

To the nautical imagery that has helped symbolize the Space Age—rocket ship, space port, Mariner, Magellan, "this new ocean"—add "becalmed," the word that best describes the U.S. space program's stagnation.

The blueprint for the Space Age unfolded in October 1951 at the Hayden Planetarium in New York. There, Wernher von Braun presided over the First Annual Symposium on Space Travel, and the small galaxy of visionaries in attendance laid out the plan against which all subsequent plans have been measured. Its heart was the "conquest" of space by men who were to fly shuttles on a series of missions to build a doughnut-shaped station rotating in permanent Earth orbit. Most importantly, the station would itself be an embarkation point for an expedition to start a colony on Mars. The phenomenally ambitious program was depicted in eight installments in *Collier's* magazine from 1952 to 1954 (at 15 cents an issue).

In this plan and in later embellishments by thinkers like Arthur C. Clarke, Isaac Asimov, Gerard K. O'Neill, and Carl Sagan, moving into space was seen as an expression of manifest destiny. But it was subverted by President John F. Kennedy's decision in 1961 to send astronauts to the moon. Apollo was the greatest feat of human exploration in history, an unparalleled technological and managerial *tour de force*, and a sensational propaganda triumph. But it derailed the grand scheme. Its impact was so great that it forever defined the U.S. space program, transforming it into a series of imitative, relatively short-term goals devoid of overarching purpose.

The space program started to go out of focus on December 14, 1972, when Gene Cernan, the last man on the moon, packed up and went home. It has drifted since then—with the few notable exceptions of robotic planetary exploration, such as Voyager's epic grand tour, and the triumphs of the Hubble Space Telescope.

The perfect example of how not to do a space program is the International Space Station. Its tortured history epitomizes the quagmire we are now in. President Bush has unilaterally reduced the station's structure and crew size, infuriating the European Space Agency and sending a message about the thing's very low priority to an equally indifferent public.

If the U.S. space program is to recapture public enthusiasm and restore unwavering government support, it needs a truly compelling goal. And there is one: planetary defense.

Earth's treasure can be safeguarded by creating a safe place for life and civilization's collective record off the planet. That single, overwhelmingly important goal can be achieved only through reusable spacecraft that enable continuous access to space.

The array of threats to Earth, both natural and man-made, is formidable: thermonuclear war; any of several kinds of apocalyptic terrorism, notably nuclear, chemical, or biological; the mutation of a virus—an airborne HIV, for example; a major accident or series of them involving nuclear weapons or nuclear power plants; global warming. Even a limited nuclear war would result in terrible atmospheric and other environmental contamination and planet-wide social and economic upheaval.

And then there are the asteroids. Scientists now believe that at least one asteroid has caused global damage to Earth. Earlier this year, three cosmic visitors suddenly appeared relatively close to home. The first, which was the size of a large shopping mall, passed by in January at a distance of roughly 500,000 miles, which is relatively close in astronomical terms. Two months later, a second, measuring some 200 feet, came within 300,000 miles. And in mid-June a "city-busting" rock the size of the proverbial football field came within 75,000 miles of this planet. It is estimated that several asteroids pass within moon distance of Earth every year. Astronomers like David Morrison at NASA's Ames Research Center in California and Donald K. Yeomans, who heads NASA's Near-Earth Object Program Office at the Jet Propulsion Laboratory in Pasadena, California, specialize in cataloging and analyzing potentially hazardous visitors. They and others emphasize

DAVID POVILAITIS

repeatedly that there is no foreseeable danger of a collision with an asteroid. But Yeomans, a prudent individual, called the successive passes this year "a wake-up call" for increased scrutiny.

There is of course no cause for panic. Earth is a very seaworthy spacecraft sailing through the cosmic void. But however seaworthy a vessel is, no responsible skipper would go to sea without insurance and a lifeboat. The space program should build the lifeboat.

Comprehensive planetary defense would have two basic purposes: to prevent catastrophe and, failing that, to salvage and restore a severely stricken planet. "Comprehensive" is the key concept; planetary defense would be a single program comprising several parts, some new and others already in place but in need of refinement, like programs of Earth observation.

Satellites in low orbit, such as the new, advanced Landsats, should be directed to make constant methodical observations of Earth in unprecedented detail. They could thus inventory resources and spot natural or man-made trouble in the early stages. Before a volcano erupts, for example, the ground begins to heave slightly and expand, like the crust of a frozen pie that is being heated. Satellite observation in conjunction with the use of seismometers on Earth's surface could provide warnings for evacuation. Satellites are already monitoring the breakup of the Antarctic ice shelf and the shrinking of the Aral Sea, on the border of Kazakhstan. But global warming needs to be studied more intensively, both on and off the planet. We have the equipment in place, but the efforts are fragmented and incomplete. An international body should coordinate the analysis and recommendations for action.

Determining that a killer asteroid is on a collision course with Earth is worthless unless there is a way to ward it off before impact; likewise, no good effect can come from watching Earth unless nations are prepared to act in concert to ward off catastrophe. If the whole planet gets clobbered anyway, the species needs to be spread out to guarantee survival and restore what can be restored on Earth. That's where the lifeboat comes in. We should settle a large and self-sustaining colony on the moon.

Eventually, after many generations, the colony would grow so much in size and sophistication that its members could organize and help direct recovery operations on Earth in the event of a planet-wide calamity that comes up short of exterminating everyone. If there were no one on Earth left to save, lunar colonists would be alive to preserve the species and its record. Such a level of capability and self-reliance will be attained only far in the future, but we can begin now by designing the spacecraft to transport us there and increasing current research on closed systems.

And we should establish a record or archive of Earth's collective life and civilization, including cultural and scientific records and biological specimens, so they could be replicated in the event of widespread destruction anywhere on Earth. It would not be a time capsule—time capsules become increasingly useless as time passes—but a continually updated repository. Some of us have formed an organization, the Alliance to Rescue Civilization (or ARC, as in "archive"), to create and maintain such an extensive record. Chemistry professor Robert Shapiro, my colleague at New York University, conceived the idea, and the others designing it include Steven M. Wolfe, a space specialist who was an aide to the late Representative George Brown of California; Ray Erikson, an aerospace engineer who has participated in many NASA programs; Sean Hadley, a lawyer; and myself. The Space Frontier Foundation is providing initial support.

ARC would by definition be a highly cooperative international effort, perhaps run by a new, permanent agency of the United Nations. It would not, however, be controlled by government. Its essential funding would have to come from corporations and foundations—the private sector—so it could not be held hostage by changes in political administrations or even systems over the course of decades and centuries.

Earth's treasure can be safeguarded by creating a safe place for life and civilization's collective record off the planet.

Planetary defense is an overwhelmingly compelling reason to send people to space. It is time to shed the notion that people from Earth will advance outward to our planetary neighbors because we have a genetic predisposition to explore. There is no public will to land on one or more of the planets as a political stunt and no cost-benefit analysis that supports plans to exploit other planets commercially. It is time for a space program that addresses the multiple perils faced by Earth.

William E. Burrows is a contributing editor to *Air & Space/Smithsonian* and the author of a number of books on space, including *This New Ocean: The Story of the First Space Age*.

A small group of Australian scientists made aviation history July 30 with the successful atmospheric test of a supersonic air-breathing engine in flight. Working with a budget most big science programs would consider petty cash, the team had researchers around the world rooting for them. Their road to success can only be called unique.

OUTBACK

Swooping across the south Australian outback in a rented Cessna 180 last November, Allan Paull learned the hard way that an aeronautics career doesn't teach you how to keep your lunch down while airborne. Make that barely airborne: At times Paull could have leaned out and high-fived pedestrians, had there been any in this vast wasteland. But the nerve-racking maneuvers allowed him to better scan the desert for his missing scramjet. And he had a keen incentive to find it, for the remains of his papal-mitre-shaped contraption could hold information that would help him fine-tune his second scramjet, which sat in pieces some 1,500 miles away in his lab at the University of Queensland.

The low-level aerial search failed, so he and his co-workers next took turns strapping themselves to the roof rack of a rented Toyota Land Cruiser. Balancing like skiers, they scanned the ground on either side, as the driver jostled along the route the scramjet should have overflown. They saw plenty of shrubs but no scramjet. Time to recruit reinforcements for a third outing in late February. Someone had a brainstorm: Why not enlist University of Queensland zoologists who had performed aerial surveys for kangaroos in these parts? The zoologists were accustomed to scrutinizing the monotonous landscape from airplanes without reaching for sick bags.

When working on a tight budget, it helps to be creative. It's not for nothing that Paull's scramjet has been termed a "scrounge jet." With a budget of less than $2 million ("pin money," Paull says, compared to the $185 million NASA has for its hypersonic program), Paull's four-person team managed to be at the forefront of research that

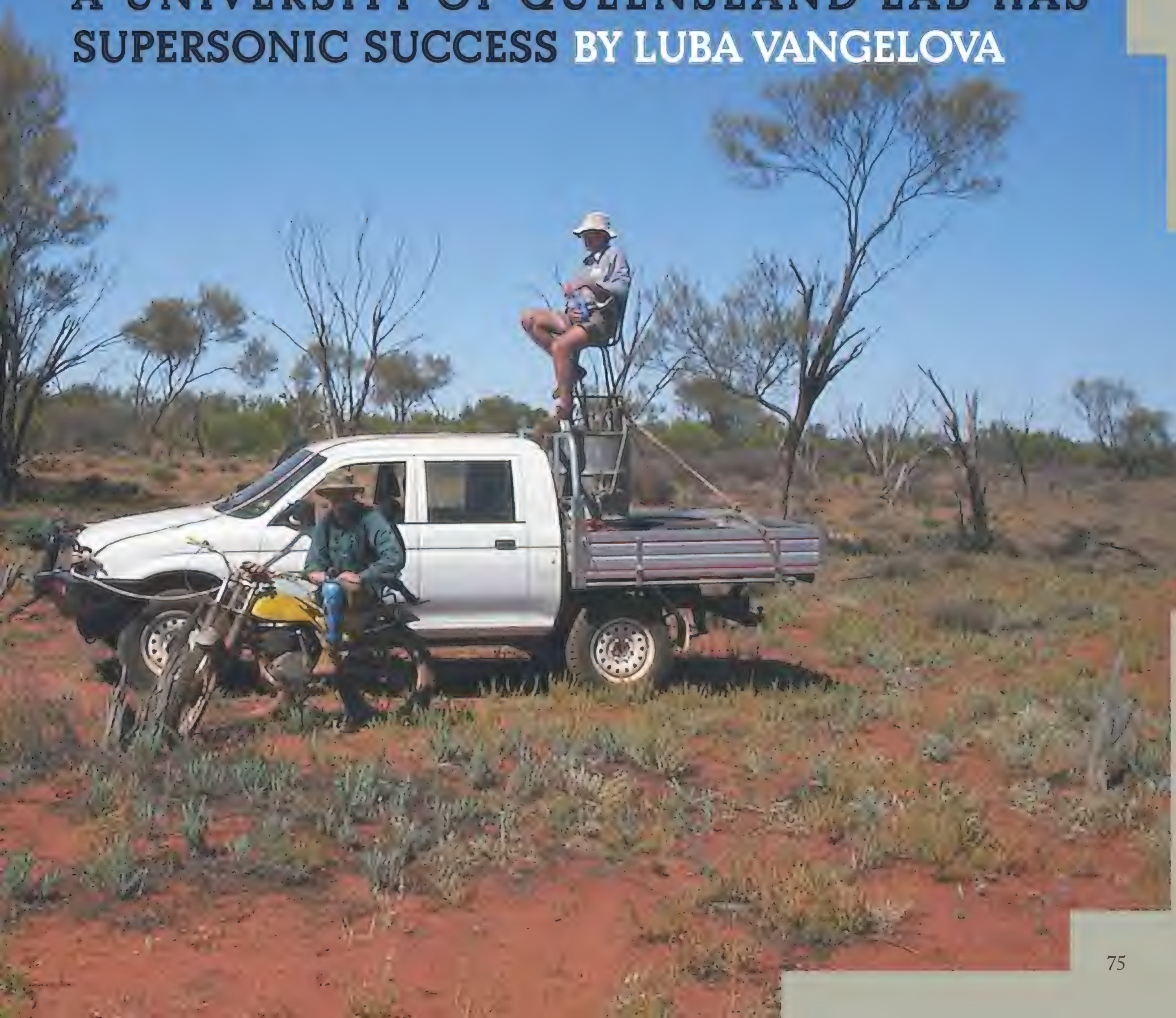
The HyShot team literally lost an engine. Opposite: Ross Paull and Myles Frost (on the motorcycle) helped search for it. Right: the scramjet, safe and sound in the laboratory.

UNIVERSITY OF QUEENSLAND CENTRE FOR HYPERSONICS; OPPOSITE: ALLAN PAULL

SCRAMJET

A UNIVERSITY OF QUEENSLAND LAB HAS SUPERSONIC SUCCESS

BY LUBA VANGELOVA



A Matter of Seconds

Before HyShot's July 30 flight added another five seconds to the tally, the few minutes of scramjet flight data that had been gathered had all come from Moscow's Central Institute of Aviation Motors. The Russian bureau conducted experiments in the 1990s, giving three scramjets rides on the noses of rocket-powered SA-5 anti-aircraft missiles. On the last launch, supported by NASA in 1998, the scramjet operated for 77 seconds with internal flows that were subsonic during parts of the flight.

Aerodynamicists have used supercomputers to simulate the airflow within scramjets, but combustion chemistry in turbulent flow has proved too complex, even for the most powerful computers. Flight tests produce far more reliable data—when they work. Had NASA's Hyper-X program succeeded last June with the launch of the X-43A, it would have added 12 seconds to the total. (The X-43A also hitched a ride on a rocket, an Orbital Sciences Pegasus, launched from the wing of a B-52 from NASA's Dryden Research Center in California.) Unlike the Australian and Russian engines, the X-43's scramjet is integrated with the vehicle's airframe. The 12-foot-long, 2,200-pound aircraft will separate from its rocket booster and fly alone through the atmosphere. The scramjet will ignite for the 12-second experment after the booster has accelerated the vehicle to Mach 7. The next launch attempt, according to program manager Lawrence Huebner, will take place in summer 2003.

In an independent effort, the U.S. Air Force is broadening the range of scramjet fuels, with an eye toward using the engines in operational missiles. Scramjets built to date, including those for the X-43A, have used hydrogen. It mixes and burns readily in an engine, but it is difficult to store and handle. The Air Force program, called HyTech, is relying on JP-7, a hydrocarbon fuel in use at most military bases.

Scramjet fuels must mix and burn far more rapidly than JP-7 can in ordinary circumstances. But the HyTech effort "cracks" the fuel's molecules, breaking them into fragments that mix and burn more easily. In the laboratory, the cracking is accomplished by heating the fuel in a separate installation, but engineers believe that in flight the heat from the engine can break down the JP-7 molecules. The fuel, circulating as a coolant through the walls of an operating scramjet, will absorb heat and crack before it is injected into the combustor.

DRYDEN FLIGHT RESEARCH CENTER

Carry on: In this drawing, the little X-43 hypersonic vehicle rides on the nose of a Pegasus rocket clinging to the wing of a B-52.

In the spring of 2000, and again in November of that year, a scramjet that had been built by Pratt & Whitney and that used cracked JP-7 as fuel produced a significant, though classified, amount of thrust in a wind tunnel. That version, built of heavy copper, weighed about 2,000 pounds and had no cooling. But a follow-on test engine using flight-weight components and weighing less than 200 pounds is now being tested with JP-7 as both the fuel and the coolant.

Program manager Robert Mercier expects to begin testing a third engine, this one a complete flight-ready system incorporating fuel pumps and valves, in 2003. In the meantime, NASA, a partner in the HyTech project, plans to develop an advanced X-43 to test the HyTech engine in flight in 2006 or 2007. The mission goal will be to accelerate under scramjet thrust from Mach 5 to Mach 7.

But first the next X-43A, which already is being prepared at the Dryden center, must collect its 12 seconds of scramjet flight data. Lawrence Huebner points out that although 12 seconds seems very short, it was the duration of the Wright brothers' first powered flight in 1903.

—T.A. Heppenheimer

may help pull off an aviation dream: inexpensive vehicles that can fly at speeds measured in miles per second rather than miles per hour.

Many see the scramjet (short for "supersonic combustion ramjet") as the key. Deceptively simple in principle, a ramjet is essentially a duct that funnels onrushing air into a combustion chamber, where it mixes with fuel. Its distinguishing feature is the way in which it raises the pressure of the incoming air in order to make the fuel self-ignite. Rather than use turbine-powered fans to compress the air, the ramjet forces the air to slow down and essentially compress itself as it passes through the engine's narrowing intake duct. The end result is the same: As they escape through the rear nozzle, the burning gases produce forward thrust.

The ramjet's simplicity offers practical advantages. It has no moving parts and therefore fewer chances for failure. It's not limited by turbine blades' inability to withstand engine temperatures associated with flying above Mach 3. In fact, the ramjet can't fly below Mach 3 (it therefore requires a conventional engine to reach that speed). But it too has its limitations: Slowing down the air to subsonic speeds generates extremely high temperatures. A ramjet can therefore operate up to only about Mach 6; to operate beyond, the engine requires so much structure that it becomes impractically heavy.

In a scramjet, this problem is circumvented by slowing the air less dramatically, so that it passes through the combustion chamber at supersonic speed. A scramjet can therefore match rocket velocities, but unlike a rocket, it uses the air's oxygen and so doesn't have to carry tanks of oxidizer. The result, in theory, is a lighter (and therefore cheaper) craft capable of flying about three times faster than the long-standing speed record for rocket-powered aircraft, set by NASA's X-15 in 1967: Mach 6.7. More tantalizing still, a scramjet's upper speed limit is unknown.

On a typically hot and humid Brisbane summer day Paull, clad in short-sleeve shirt and shorts, receives me in his un-air-conditioned office at the University of Queensland. A cartoon-emblazoned punching bag sits wedged in the gap between the credenza and the window.

With wiry, sandy hair, and blue eyes, the six-foot-three Paull could pass as Christopher Lloyd's chilled-out, antipodean cousin. Leaning back in his chair, the 42-year-old reflects on his groundbreaking work. Speaking in a broad Aussie accent, he liberally punctuates the tale with *rightos* and underscores his drier observations with a slightly mischievous smile.

In 1985, after earning a graduate degree in applied mathematics, Paull netted himself a job crunching numbers for Ray Stalker, a University of Queensland space engineer of global renown who had designed and built one of the world's most sophisticated wind tunnels at the university and used it for pioneering scramjet research. When Stalker suffered a stroke in the 1990s, Paull found himself in charge of the program. Progress remained hampered by a central limitation: Even the university's most cutting-edge shock wave tunnel allowed a test window of only two milliseconds.

Then opportunity came knocking, in the form of a Florida-based company called Astrotech Space Operations. The company had no interest in scramjets per se; it merely wanted to expand its sounding rocket business (selling cargo space for microgravity science experiments) into the Asia-Pacific region. What better way to make a public relations splash than by carrying "some sexy payload," in Paull's words, on the two demonstration flights the company had

UNIVERSITY OF QUEENSLAND CENTRE FOR HYPERSONICS (2)

When Allan Paull (left) needed skilled but cheap labor, he asked his dad, who helped out with the engine's wiring.

planned? An intermediary made the introductions, and in 1998 the two parties signed an agreement. Astrotech would provide the Terrier-Orion rockets for two launches; Paull would equip them with a cutting-edge scramjet experiment. The HyShot program was born.

Now the pressure was on: "We had to figure out how to make the engine fly and not fall apart" in a test time window hundreds of times longer than the one available in wind tunnels, Paull says.

Space programs from around the globe have tried to tackle the same perplexing dilemma for decades. The United States and Russia, in particular, have invested millions. What's the carrot motivating their research? First and fore-

Shock waves form around a model of the Terrier-Orion carrier rocket in a Farnborough, England wind tunnel.

most, they hope one day to use scramjets as a cost-effective rocket replacement in space launch vehicles. Military planners want to add hypersonic missiles to their arsenals. On the commercial end of things, a scramjet-powered passenger airplane could, in theory, reduce travel time, allowing you to fly from, say, London to Sydney in two hours.

Indeed, eyeing such payoffs, the U.S. government began funding scramjet research in the 1960s; it now sponsors some half a dozen scramjet programs in the Department of Defense and NASA (see "A Matter of Seconds," p. 76). Since 1994, NASA has worked with the much-lauded Russian program, which has launched some of the most successful tests to date. Today, half a dozen other countries have substantive programs as well.

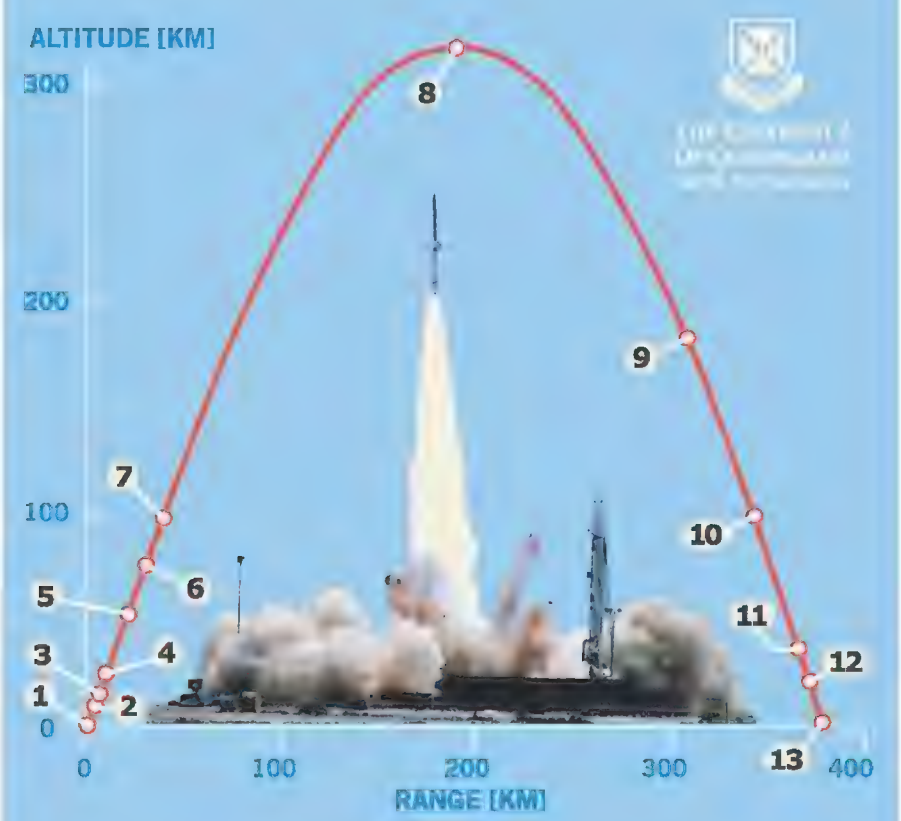
Yet for half a century the scramjet has remained (excuse the pun) a pipe dream. Putting the simple theory into practice is fraught with engineering challenges. To begin with, there is the difficulty of igniting fuel with air that is traveling at supersonic speed. "It is like lighting a match in the middle of a blowing hurricane," says Robert Mercier, head of HyTech, the U.S. Air Force's scramjet program, located at Wright-Patterson Air Force Base in Ohio.

UNIVERSITY OF QUEENSLAND CENTRE FOR HYPERSONICS

In early experiments at the University of Queensland, a small scramjet produced net thrust in a wind tunnel.

HyShot Mission Profile

The mission flew a steeply parabolic trajectory with a near vertical descent so that during the brief test time, the scramjet would travel through a range of ambient pressures. During the five seconds of supersonic combustion, measurements of pressure and temperature in the combustor were transmitted to three ground stations.



1) 1st stage ignites, 2) 1st stage burns out, 3) stages separate, 4) 2nd stage ignites, 5) 2nd stage burns out, 6) nosecone ejects, 7) attitude control maneuvers begin, 8) rocket reaches apogee, 9) attitude control maneuvers stop, 10) payload re-enters atmosphere, 11) scramjet ignites, 12) combustion stops, 13) impact.

Then there is the heat issue: A vehicle traveling that fast can reach a temperature of 3,600 degrees Fahrenheit—similar to what the Apollo capsule experienced on reentry, and hot enough to warp, if not melt, most materials. (Some researchers are experimenting with heat-absorbing fuels that, prior to combustion, would circulate through channels in the engine walls to cool them down.) Also, to work effectively, scramjets must be integrated with the airframe; how best to do this remains a question.

The most advanced wind tunnels can accelerate a scramjet model to the required speeds and temperatures for only a few milliseconds. But actual flight tests are expensive, logistically challenging, and considerably vulnerable to things going wrong.

Just ask NASA. In June 2001, the agency hoped to record the first scramjet-powered hypersonic flight in a much-ballyhooed trial (the first of three in its Hyper-X program) off the California coast. But the rocket booster malfunctioned and, before the scramjet could be released to allow the real experiment to begin, propelled itself and its payload straight into the Pacific Ocean.

Because different scramjet teams have focused on different pieces of the research puzzle and pursued slightly different near-term goals, the question of who can rightfully claim some nominal "first" usually hinges on semantics and nuances; "It's a bit fuzzy," Paull says. What is beyond dispute is that until July 30 no one had demonstrated purely supersonic combustion in a scramjet hurtling unaided through the atmosphere.

The scramjet rode as the payload on a Terrier-Orion sounding rocket, which flew into space in a parabolic arc. The scramjet separated from the booster on the upward trajectory, rotated at its apogee toward Earth, and eventually operated for five seconds (at a speed of almost Mach 8) before it hit the ground. Attached instruments measured var-

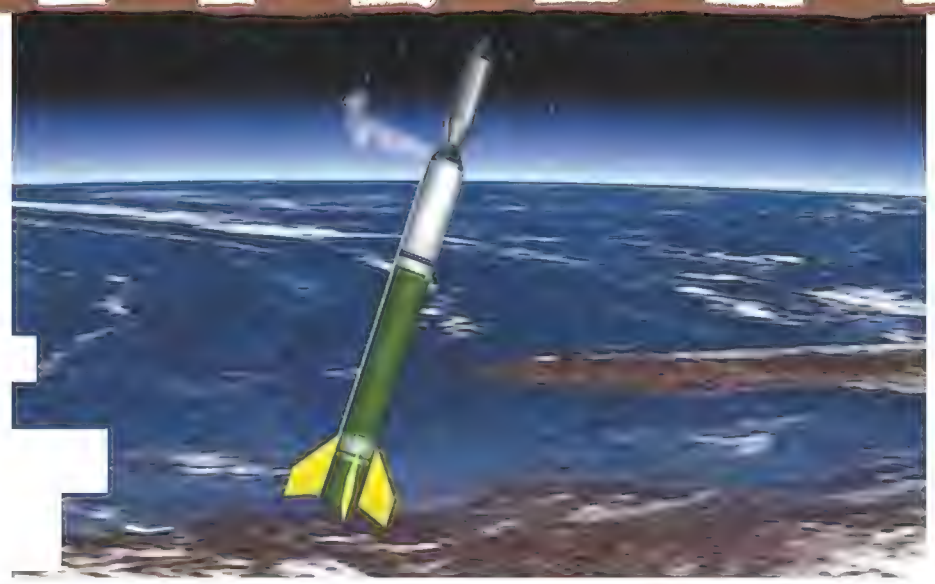
Fewer than 400 people live in the town of Woomera, which exists solely to support the rocket range.

ious parameters and transmitted a stream of data that researchers can now use to calibrate their design, analysis, and test tools to real flight conditions.

The promise of such data prompted researchers on the other side of the world to pay close attention to Paull's HyShot program—so much so that NASA even became one of its sponsors. "We're very hungry for flight data," says Lawrence Huebner, manager of the Hyper-X scramjet propulsion program at NASA's Langley Research Center in Virginia.

So what crucial decisions did Paull and company make to eventually achieve what Paull himself called their "beautiful" second launch? To start, Paull hired Hans Alesi, a German-Australian aerospace engineer who had read about HyShot and called to offer his services. Together the two men scrutinized potential engine designs, "trying to figure out how they could go wrong," Paull recalls. "It's like going out on a first date. There are a lot of 'what ifs.' " They needed something that could withstand high temperatures, conduct heat well and did not bust their budget. They settled on an alloy of silver and copper, then commissioned university technicians to build it. The final result: a scramjet about half the size necessary to generate enough thrust to propel a craft, but large enough for their experiment.

Next they had to design and build the scramjet's instrumentation module, which would control the flight and collect and transmit data. Several unexpected and time-consuming problems surfaced. Developing and testing a sophisticated attitude control device took a year and proved



UNIVERSITY OF QUEENSLAND CENTRE FOR HYPERSONICS

An artist's view of the rocket just before thrusters turn it nose-down, a maneuver requiring 50 individual pulses.

"a bigger challenge than the scramjet," Alesi says in a lilting German accent. Paull and Alesi also had to design some of their payload test tools, such as a three-axis gimbal to simulate how the payload might rotate at the height of its trajectory.

The hitch-a-ride-on-a-sounding-rocket strategy was cheap, but was it cheap enough? As the HyShot timetable doubled and then tripled, Paull began to wonder if the team would run out of funds.

The University of Queensland, the Australian government, and QinetiQ (the privatized arm of Britain's military research agency) had provided seed money for the project. Paull eventually secured additional funding from NASA, the German and Japanese space agencies, Korea's Seoul National University, and several Australian companies. Part of the appeal for the sponsors was Paull's "clever and cheap way of getting this data," says Terry Cain, a research fellow at QinetiQ, which is testing its own scramjet engine at one of the university shock tunnels.

Then, to stretch their modest budget, the team members got even more resourceful. Paull assigned students scramjet-related projects and in myriad other ways convinced people "to do things for free," he laughs.

Some expenses were unavoidable: Wind tunnel tests (conducted an average of twice a day) cost about $500 per shot. To run them and also help out with other testing, Paull eventually hired one of his former graduate students, Myles Frost.

Lacking the resources to hire an expert for each task, he and his team members each wore many hats; Alesi sometimes found himself standing at a mill or a lathe, manufacturing some component for the payload. But they all say their big-picture perspectives encouraged them to come up with innovative solutions. Paull offers one such example: Forced to devise something that "weighed a kilo but could hold a ton" to keep the payload in place on the launch pad, Alesi designed a retractable lug that a private company has since expressed interest in buying.

Paull's other big challenge was what he describes as an "amazing legal nightmare." Like some B-grade horror movie plague, it ate up half his time, even after he hired another former graduate student, Susan Anderson, to help keep it

Kangeroo spotters from the University of Queensland saved the day by spying wreckage from the first scramjet test. The circle indicates the area of impact.

COURTESY GORDON GRIGG; INSET: ENVIRONMENT ACT, AUSTRALIA

at bay. The team had to secure authorizations from various state government agencies, coordinate with aviation bodies and insurance companies in both Australia and the United States (because of the involvement of U.S. funding), perform environmental assessments, and ensure their launch debris would steer clear of land claimed by Aboriginal tribes. They even had to visit area ranchers in person to allay their concerns. To complicate matters, the Australian government then grew jittery about anything taking place so close to a highly controversial refugee detention center. All told, the preparations took three and a half years. There were moments during that time when Paull wondered if transferring to a better funded program somewhere else might be the only way to fly a scramjet.

But surprisingly, at least to him, Paull had become something of a celebrity. In an isolated country accustomed to being a bit player on the world stage, his cutting-edge work was drawing considerable attention. Australian media coverage fired public enthusiasm to the point where new acquaintances congratulated Paull whenever he mentioned his work. HyShot was sometimes cast as a David versus Goliath affair, appealing to Australians' affection for "battlers" persevering against all odds. "The strong effort we put in was appreciated," Paull says. With that kind of moral support, "I couldn't turn around and defect [to a program overseas] just to get the job done."

Yet as the launch date drew closer, the prospects of meeting the deadline grew dimmer. Time to call in some family favors. During his student days, Paull had occasionally helped his father, Bert, who installed and maintained movie theater equipment, on emergency repair jobs. Now it was the 73-year-old retired father's turn to step in and lend a hand. Scramjet electrical wiring may not have been part of Bert's job description in the "picture business," which he entered back when biplanes served the more isolated towns in his vast territory. But the fundamentals hadn't changed: "All wires have got two ends," he points out good-naturedly. Over the course of a month, Bert took time away from lawn-mowing and other pastimes (notably, monitoring airplane cockpit transmissions on his scanner radios) to install more than 40 yards of cables inside the payload and on the launch pad.

Also stepping up to the plate was Allan's older brother Ross, an applied mathematician who had run his own machine tool business for more than 20 years. Ross helped develop the flight control software; he also lent a hand with the electrical work. Alesi says the family's cutting-up helped take the edge off the many late nights and weekends on the job.

Finally, the day of reckoning drew near. In late October, Paull and his teammates drove halfway across the country with their precious cargo on the back of a utility truck. Paull's family followed in their own cars. Their destination: Woomera Instrumented Range, a speck in the desert 300 miles north of Adelaide.

"We knew the whole thing was fraught with problems," Paull admits.

The launch itself went off without a hitch. But then the second-stage rocket veered off course and disappeared over the outback. Having experienced a similar misfortune, NASA's Lawrence Huebner concludes with a laugh, "Rockets don't want scramjets to take over their job."

Paull admits that his own team lost momentum after that first failed test. Alesi, seeking more financial security for his young family, left to work for Boeing in the United States. Ross Paull took his place, and the team took up the challenge of finding their missing scramjet. Both the Royal Australian Air Force (which had sent a reconnaissance helicopter soon after the launch) and Paull's own search-and-recovery efforts had been more search than recovery, until the University of Queensland kangaroo spotters signed on for the job. By a bizarre coincidence, the likely points of impact lay within their annual survey area.

The new recruits went airborne but saw little of note the first two days, aside from the extraordinary sight of Paull teetering on a stool set atop an upright oil drum, the entire ensemble strapped to the roof of the four-wheel-drive vehicle he and his brother were using for their concurrent ground search. Eventually, someone in the airplane spied a grounded rocket. But hopes were dashed as quickly as they'd been raised when, upon closer inspection, it turned out to belong to some mystery third party.

Finally, on the third day, their optimism now flagging, one of the zoologists spotted something resembling a rubbish dump. The absence of wheel tracks suggested it might have fallen from the sky. Zoologist Gordon Grigg radioed Paull and company, who raced to the sight. "We could tell from their body language it was the right one," Grigg says. "Myles, the first to arrive on the scene, began pointing very excitedly and jumping up and down."

An analysis of the wreckage helped the crew prepare their second prototype. They worked furiously to meet their self-imposed deadline of July 30, 2002, for the second launch. This time the Terrier-Orion Mk70 rocket did its job and took the scramjet into the upper atmosphere, where it kicked in 22 miles above Earth, reaching speeds of more than 5,000 mph before ramming into the ground.

No flawed leftovers for the kangeroo spotters to find this time.

HyShot's hotshot crew and fellow scramjet hunters (from left): Tony Pople, Myles Frost, Allan Paull, Lyn Beard, Gordon Grigg, Ross Paull, and David Boothey.

COURTESY GORDON GRIGG

SIGHTINGS

In September 2001, after the aerial attacks on the World Trade Center and the Pentagon, the Reno National Championship Air Races, along with the National Business Aviation Association convention in New Orleans, the Tennessee Aviation Days airshow in Smyrna, the California International Airshow at Salinas, the Neptune Festival airshow in Virginia Beach—and pretty much every other flying event in the nation—were poised to occur in areas that had suddenly become no-fly zones.

At Reno, photographer Richard Vander Meulen, like other visitors, had flown in a couple of days before the September 13–16 event. His pictures remind us of that week of perfect flying weather and no flying. "Never in my life have I experienced anything so quiet as that silent sky," he says. "No roar of racers on the course, no small aircraft in the distance, no airliners high overhead. To me, Reno 2001 will always be Silent September."

A usually raucous crowd wandered

the grounds somberly, admiring the airplanes that had made it in before all air traffic was grounded, such as the Formula One *Miss USA*, which carried the flag for the duration (opposite, left). "The racers were all there," says airshow announcer Frank Kingston Smith. "It was the spectators, who come from around the world, who couldn't get in."

"Race qualifying days became days of watching small groups of race crew members, fans, friends, and media quietly sharing anger and grief," says Vander Meulen. Instead of filling the grandstand for the races, people gathered at the television in the Reno Air Racing Association hangar.

In the grandstands, Tina Della, Susie Lyles, Maxine Zimmerman, and Jerry Della, all from Reno, joined hands and observed a moment of silence with the rest of the audience (left to right, above). Frank Kingston Smith asked Experimental Aircraft Association founder Paul Poberezny to share his thoughts on September 11 and its aftermath with the audience (left); and a Reno musician climbed an airstair to play the mournful "Taps" (opposite, top).

The Universe on Your Desktop

Starry Night. Space.com, www.starrynight.com. *Beginner, $29.95; Backyard, $49.95; Pro, $129.95.*

Redshift 4. Cinegram Media, Inc., www.cinegram.com. *$59.95.*

The Sky. Software Bisque, www.bisque.com. *Level II, $129.00; Level III, $199.00; Level IV, $249.00.*

DAVID CLARK

These programs amount to precise working models of the universe that engage users in ways that books simply cannot, and even the simplest of them offers myriad features and tools to aid in desktop exploration.

All three packages are new versions. Both *The Sky* and *Starry Night* have versions for beginners, more serious enthusiasts, and advanced amateur observers, while *Redshift 4* shoots squarely at the middle. All three have equally precise celestial mechanics engines—the complex calculations that enable the programs to determine and display objects' positions in the heavens at any given time—but vary in the way information is presented and the volume of data that is included.

The user interface—determining how much information to show on the screen, how to differentiate objects, and how the user controls the view—will dictate how much the software gets used. Though generally a very capable program, *Redshift 4* is the least successful in this respect. The graphics, particularly the symbols for galaxies and globular clusters, are garishly colored and oversized and clutter the screen. The only way to adjust them is to turn them off altogether. On the other hand, *Redshift 4* has appealing features, including an astronomy dictionary and the option of viewing events, such as eclipses, from multiple locations simultaneously.

The *Starry Night* family is perhaps the most aesthetically pleasing of the bunch. The twilight and dawn views are beautifully rendered, and the object symbols—galaxies, clusters, nebulas—are discreet yet clear. They include several animations that help users comprehend the scale of the solar system, galaxy, and universe, as well as the motions of objects within each. Other features are particularly helpful to amateur astronomers: *Night Vision* adjusts the screen to a dim red, which allows astronomers to use the program on a laptop in the field without damaging their night vision. Another option converts the screen images to black stars on a white background, which is how most star atlases are printed. You can also flip your image to see how it would look in an astronomical telescope and print out charts to match those views.

The Sky is by far the most sophisticated package, and for active amateur astronomers eager to plan efficient observing or astrophotography schedules, this is the way to go. *The Sky*'s databases surpass the other two programs substantially in terms of the number of objects available: Level IV can show up to 600 million objects, and the number of options, including detailed object reports, tracking of man-made satellites, and the ability to track stellar motions over hundreds of years, make this program useful to both amateurs and professionals. *The Sky* also requires the most patience on the part of the user, as it takes time to learn how to activate and deactivate certain options, and moving around the sky is considerably more challenging. Unfortunately, the user interface is not nearly as aesthetically pleasing as *Starry Night*'s. While *Starry Night* shows trees and rocks on the

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ground if the view is set near the horizon and shows life-like details on the planets (Saturn's ring divisions, Jupiter's cloud belts), *The Sky* is all business—the ground is merely a green surface, and the planets are simple shaded disks.

All these programs allow users to examine sky objects from any location on Earth, learn constellation patterns, and study the nebulas, galaxies, and planets at magnifications most often used in amateur telescopes.

One of their most useful benefits helps users grasp the way the universe actually moves. With some simple adjustments of location, fields of view, displays, and preferences, the software can advance or recede through time, producing film-like simulations of the motions of the planets around the sun, and the continuous changing of the constellations' positions as the seasons advance.
—Eric Adams is a former associate editor of Air & Space/Smithsonian.

AT THE MOVIES

Apollo 13: The IMAX Experience

Apollo 13, the movie about the ill-fated moon mission, was, by all Hollywood standards, a big movie. Created by Imagine Entertainment, it featured a respected director, Ron Howard; a major box office star, Tom Hanks; and other stellar cast members.

Last September, some seven years after it was first released, *Apollo 13* got even bigger—six stories bigger. And it's making a little history of its own as the first live-action Hollywood movie to be transferred into an "IMAX Experience"—and onto the trademark screens that stand 80 feet tall and 120 feet wide. IMAX has been working on a way to remaster and resize some of the great movies to its 15/70-mm format so they can be shown at the 225 IMAX theaters around the world.

Earlier this year, the proprietary software to make it happen, IMAX DMR (Digital Re-mastering), was ready to test. When producer Brian Grazer took the phone call inviting *Apollo 13* team members to view selected segments, he and the others were "flattered" and "intrigued," he recalls—and they also had reservations. Howard, Hanks, and Grazer were concerned that the performances and dialogue would be lost amid the huge images. Then there were the close-ups. Facial blemishes could take on a whole new dimension, Hanks points out: "If your head is eight stories tall, you could have a pimple the size of a Volkswagen bus." But when they saw the tests, "we were blown away," says Howard.

On the eve of *Apollo 13*'s latest launch, film companies and producers were lining up as IMAX executives began mulling over other movies to "reimagine" with the new technology. IMAX-izing a film is affordable as Hollywood budgets go—from $2 million to $3 million—and takes as little as three months. IMAX, however, has announced that it will stay true to its educational entertainment roots. "We will be highly selective," assures Bradley J. Wechsler, IMAX co-CEO-chairman. In other words, you won't be seeing *Dumb & Dumber* coming to an IMAX near you.
—A.J.S. Rayl

The Complete Idiot's Guide to NASA

by Thomas D. Jones and Michael Benson. Alpha Books, 2002. 335 pp., $18.95 (paperback).

To the list of how-to guides for complete idiots—"The Complete Idiot's Guide to Creating a Web Page," "to Playing Guitar," "to Real Estate Investing"—now add "to NASA." I must be a complete idiot, because I thoroughly enjoyed it.

Written by four-time shuttle astronaut Thomas D. Jones and author Michael Benson, the volume has two main components: a history of rocketry from 13th century China through the International Space Station, and a description of how NASA works, including mission-by-mission profiles. There's a perforated reference card of the early manned space flights, plenty of chatty narrative, and black-and-white photos on nearly every spread. It's like an encyclopedia with personality. There are also lots of boxes: Cosmic Facts ("Each Skylab astronaut received 4.2 pounds of food per day, including packaging"), Space Talk ("The white room is the small compartment on the gantry that fits around the spacecraft…"), and Dr. Jones's Corner ("Schirra's mood aboard Apollo 7 was not helped by the fact that shortly after launch he came down with a serious head cold"). Each astronaut from Alan Shepard through the crew of Skylab 4 gets his or her own bio. (No one following—the shuttle astronauts, the ISS inhabitants—gets much verbiage.)

If the book has any problems, they lie in its non-critical view, an almost defensive support, of the space agency. The authors gloss over the *Challenger* disaster, and they go a little easy on Russia's "contribution" or lack thereof to the ISS. But they do mention all notable disasters, from Vanguard's every launch pad explosion and the Apollo 1 fire to each failure to reach Mars.
—Phil Scott is a frequent contributor to Air & Space/Smithsonian.

PORTRAITS

Flying High: Pioneer Women in American Aviation

by Charles Mitchell and Kirk House. Arcadia, 2002. 128 pp., $19.99 (paperback).

Was there ever a more appealing pilot than Harriet Quimby? Slender and coiffed, she wore a tailored purple jumpsuit and knee-high boots. Alas, there were no seat belts in 1912: She fell to her death when her airplane inverted at the Harvard Air Meet over Boston Harbor.

Early death was a common fate for the Bird Girls, as newspapers and billboards called them. Their faces haunt the pages of this collection of photographs and captions, even those who time permitted to become little old ladies with large spectacles.

The photos are mostly from the Glenn Curtiss Museum, so the coverage is uneven: I'd expected to see more of Amelia Earhart, and Pancho Barnes isn't shown at all. But I'm glad to have these snapshots of the Bird Girls, most of whom I had known only as faces on postage stamps.
—Daniel Ford's latest book is a new edition of The Lady and the Tigers, *detailing Olga Greenlaw's year with the American Volunteer Group.*

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"I often work through the night and need to sleep during the day. Now I go right to sleep despite the traffic noise and the daytime sounds of my neighborhood. Thanks!"

–M.B.C., New York, NY

Sleep-eze™ is Completely Safe and Drug-free

Sleep-eze is a battery-powered sleep aid designed by a professional audiologist. Incorporating advanced technology, it fits almost invisibly in your ear, weighs less than one ounce and travels with you anywhere in the world. After just a couple of minutes, you'll feel like there's nothing there at all. *Sleep-eze is not a drug, herb or pill and never requires a prescription.*

Say goodbye to tossing, turning, sleepless nights and interrupted naps. Awaken refreshed and ready to seize the day!

The Scientifically Engineered Personal Noise Eliminator

Sleep-eze is essentially an electronic noise cancellation device. It generates its own sounds that hide or "cancel" outside noise—precisely the noise that makes it hard for you to sleep. Think of being at the ocean. You hear the waves, but not much else, even if there's quite a commotion going on.

"I used to sleep 4-5 hours, wake up and, if I was lucky, fall asleep 2 or 3 hours later. Now, when I wake up, I put Sleep-eze on, and I fall asleep in minutes!"

–G.W., Palm Beach Gardens, FL

Sleep-eze Works Everywhere

With Sleep-eze, you gain blissful sleep even in the midst of:

- Your partner's snoring
- Kids playing
- Loud stereos, televisions and phone conversations
- Air travel

And Sleep-eze is not just for couples. It's also perfect for anyone who needs peace and quiet when:

- Working in noisy offices
- Reading or studying
- Relaxing or meditating

Special Offer

If you order within the next 10 days, we'll send you the following items—normally a $49 value—absolutely free:

- 6 month supply of batteries
- Special case and traveling pouch
- Our booklet, "Ten Secrets to Getting a Sounder Night's Sleep"

Whether you buy it for yourself or a loved one, Sleep-eze will make a big difference in both of your lives. And if you snore, Sleep-eze makes a great present for your spouse!

"Thanks to Sleep-eze, my husband and I sleep in the same room again. I wish I'd known about your company earlier!"

–L.C., Sarasota, FL

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dept. SM102

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Sleep-eze may look simple, but inside each one is a tiny yet highly sophisticated technology that instantly masks noise that prevents you from sleeping or getting quiet time.

To order by mail: send check or money order payable to Sleep-eze for the total amount, including S&H. To charge to your credit card (Visa, MC, Discover), enclose your card number, expiration date and phone number. Florida residents only: please include sales tax. Mail to: Sleep-eze, Dept. SM102, 1219 Tallevast Rd., Sarasota, FL 34243.

Order two pair or more and receive an extra 10% off your entire order!

Your Sleep-eze purchase is backed by our unconditional 30-day money back guarantee.

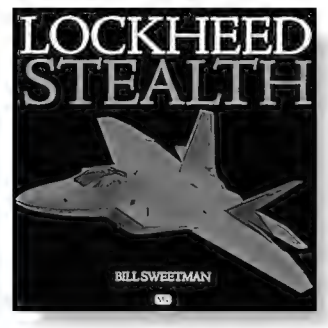
Lockheed Stealth

by Bill Sweetman. MBI Publishing, 2001. 168 pp., $ 29.95.

Two decades ago, writing for *New Scientist*, Bill Sweetman was hard-pressed to fill four pages about stealth, which enables a warplane to elude detection by radar. Today, stealth fills volumes. True stealth enables an aircraft to fly undetected not merely by radar but also by sound and heat sensors. It's essential to success in combat.

Or is it? In the secret world of "black" programs, Lockheed's Skunk Works bypassed bureaucratic impediments to give us the U-2 and SR-71 reconnaissance aircraft and the F-117 Nighthawk stealth fighter. The F-117 may have been the most successful aircraft undertaking of recent decades, carried out at a base in the Nevada desert far from prying eyes—and more importantly, far from the Capitol Hill denizens who seek to infuse every military program with political pork. But Sweetman, an authority on stealth, argues that secrecy has fostered industrial indifference to the huge advantage stealth offers.

The newest combat aircraft, the F/A-18E/F and the F-35 Joint Strike Fighter, were designed without stealth as a primary consideration. The Super Hornet has almost no radar-evading capability, and the F-35 employs some stealthy design features only as an afterthought. Sweetman says he is "alarmed" that a next generation of stealth capabilities is not being developed.



Through no fault of the author, this account of stealth is cluttered with jargon and acronyms, and *Lockheed Stealth* doesn't have a single photo that hasn't appeared elsewhere. When shall we see early U-2 and F-117 pictures that have not been released? Sweetman argues that no one benefits when the Pentagon continues to withhold details and photos of stealth experiments. When, for example, will the Air Force release drawings of Northrop's F-117 competitor, which was apparently built but never flown?

—Robert F. Dorr, an Air Force veteran in Oakton, Virginia, is the author of Lockheed F-117 Nighthawk.

Disaster at the Pole

by Wilbur Cross. Lyons Press, 2000. 316 pp., $16.95 (paperback).

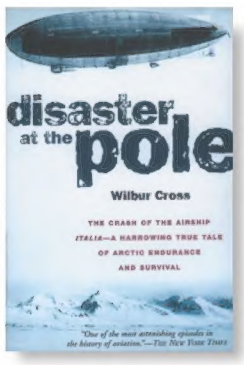
In the summer of 1928, a little red tent held all of Europe rapt. *Disaster at the Pole* recounts the gripping story of the airship *Italia*'s Arctic crash, the perseverance of its stranded survivors, and the discombobulated rescue efforts—the largest undertaking in polar history.

In 1926, when the North Pole was still largely unknown, General Umberto Nobile, one of Italy's finest aeronautical engineers, teamed with Norwegian explorer Roald Amundsen to fly the dirigible *Norge* over the pole, a first for a lighter-than-air craft. An encouraged Nobile set out in 1928 on a more ambitious effort: landing at the pole.

The *Italia* reached its destination, but during the return home, it crashed on an ice floe. With only limited equipment recovered from the crash, nine survivors, including an injured Nobile, spent seven weeks radioing for help in freezing temperatures on a creaking, breaking floe. Three men left on a doomed trek to seek help, while others erected a red tent for camp. For reconnaissance missions, spotting the tent from the air became the intense search for the tiniest speck of color in the vast Arctic white.

Seven countries organized recovery attempts by land, sea, and air—many of them hastily conceived out of pride rather than altruism—and some rescuers, including Amundsen, did not survive.

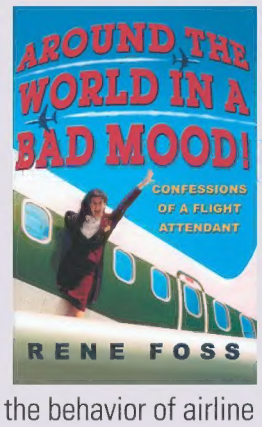
Using extensive interviews he conducted with every survivor in the 1950s, Cross re-creates a detailed account of the survival and its stunning political aftermath. But aviation aficionados beware: Those seeking an in-depth discussion on dirigibles will be disappointed. A revised edition of Cross' 1960 book, *Ghost Ship of the Pole*, this book is a story of survival done mostly right and rescue done mostly wrong, with little discussion of aviation. Still, as a former *Life* editor and author of more than 45 books, Cross brings to life in swift prose a captivating story of courage and endurance.



—Mark Greer will graduate from the Medill School of Journalism in Evanston, Illinois, in 2003.

LITE FARE

Around the World in a Bad Mood! Confessions of a Flight Attendant



by Rene Foss. Hyperion, 2002. 200 pp., $12.95 (paperback).

True to its title, *Around the World* is a catalog of the thoughts behind the beauty-pageant smile on a flight attendant—the good, the bad, and the ugly. Mostly ugly, when it comes to the behavior of airline passengers. Some of the stories Rene Foss relates seem more urban legend than fact: When one passenger presented an attendant with an infant and demanded that it be changed, the attendant allegedly took the child, swapped it with another infant in the back of the cabin, and presented the borrowed baby to the demander.

Easily digested in an hour, this is a perfect read for an East Coast shuttle flight, or maybe on board what Foss calls WAFTI: "We Apologize For This Inconvenience Airline."

CREDITS

Ration of Luck. Retired from both the Central Intelligence Agency and the U.S. Marine Corps Reserve, Donald V. Courtney lives in rural Montana, "a far piece from town." He now pushes his luck only with his tractor, chainsaw, clutch of hunting rifles, and his wife of 38 years.

Sikorsky's Piano Man. Vadim Prokhorov is an author and composer. His book, *Russian Folk Songs: Musical Genres and History*, was published by Scarecrow Press in 2001. He is the author of numerous articles on classical music in the Encyclopedia Americana.

Shoot 'Em Up. Carl Hoffman is a frequent contributor and the author of *Hunting Warbirds: The Obsessive Quest for the Lost Aircraft of World War II.*

Chad Slattery is a Los Angeles-based photographer who specializes in aviation; his work can be viewed at *www.aeropix.com.* Photographing at China Lake reminded him of his boyhood days, firing away with a .22 rifle.

Restoration: Mach 2 Heavyweight Champion. Robert F. Dorr is a U.S. Air Force veteran, a retired career diplomat, and an author who lives in Oakton, Virginia, with his family and Labrador retriever.

Project 921. Joe McDonald is a reporter based in Beijing.

How Things Work: Supersonic Inlets. Diane Tedeschi is an associate editor at *Air & Space/ Smithsonian.*

São Paulo Traffic Report. Carl A. Posey is an occasional contributor whose last Brazil story for *Air & Space* was on the evolving space program there (Oct./Nov. 1997).

All That Remains. Phoenix, Arizona pilot and writer Howard James Stansfield wrote "The Unemployment Line," which appeared in the last issue.

Commercial and editorial photographer Dan Coogan has lived in the Phoenix area since 1990. His Web site is *www.CooganPhoto.com.*

Sky High. George J. Marrett is working on a memoir about flying cover for search-and-rescue missions in Vietnam. He can be e-mailed at *jmarrett@tcsn.net.*

Outback Scramjet. Luba Vangelova is a freelance U.S. writer based in Sydney, Australia. She has written for *National Geographic Traveler* and the *New York Times*, among other publications.

"A Matter of Seconds": Frequent contributor T.A. Heppenheimer lives in Fountain Valley, California, and is writing a history of hypersonic research for NASA.

CALENDAR

October 5 & 6
Fina-Commemorative Air Force Airsho. Midland International Airport, TX, (915) 563-1000, *www.commemorative airforce.org.*

October 6
Annual Omelet Brunch. Castle Air Museum, Atwater, CA, (209) 723-2178, *www.elite.net/castle-air.*

October 10–13
Copperstate Regional Experimental Aircraft Association Fly-In. Free flights in general aviation aircraft, wing-rib-building class for children, and airplane construction workshops. Phoenix Regional Airport, AZ, (520) 400-8887, *www.copperstate.org.*

October 11 & 12
Reunion: Webb Air Force Base personnel. Hangar 25 Air Museum, Big Spring, TX, (915) 264-1999.

October 12 & 13
Festival of Freedom. Dozens of modern and vintage aircraft on static display, flight demonstrations, tanks and armored vehicles, historical event reenactors, and live music. Manassas Regional Airport, VA, (703) 830-6031.

October 19 & November 23
Experimental Aircraft Association Chapter 908 Fly-In Pancake Breakfast. St. Lucie County Airport, Fort Pierce, FL, (772) 464-0538.

October 24–26
Aircraft Owners and Pilots Association EXPO. Palm Springs Convention Center, Palm Springs, FL, (301) 695-2162.

November 5
Wright Brothers Forum. Panel discussions and demonstrations examine how the Wright brothers achieved powered flight. Join a discussion on the Wrights' kite and glider activities. Meet descendants of the Kill Devil Hills lifeguards who witnessed the 1903 flights. See the 1903 Wright *Flyer* reproduction that will fly at the Aviation World's Fair in April 2003. Virginia Aviation Museum, Richmond International Airport, VA, (804) 864-1400 ext. 1405, *www.vam.smv.org.*

Organizations wishing to have events published in Calendar should fax press releases two months in advance to (202) 275-1886 or mail them to Calendar, Air & Space/Smithsonian, *MRC 951, P.O. Box 37012, Washington, DC 20013-7012.*

FORECAST

In the Wings...

CAROLINE SHEEN

Chalk's G-73Ts are making a splash.

SPECIAL SECTION: WATERWORLD

Chalk's Ocean Airways
An airline with gangsters in its past and saltwater in its blood, Chalk's has reclaimed its Florida home with Grumman Turbine Mallards.

Emily's Offspring
ShinMaywa's stately flying boats honor their World War II Nakashima ancestors.

The World's Great Seaplanes
Paintings by the well-known nautical artist Ian Murphy, including the Boeing B-314, the Martin M-130, and the Short S-23 Empire.

Four Flyers
The Wright brothers built one airplane in 1903. So how come no two of these replicas are alike?

Centennial Celebration
Coming in February/March 2003: a special commemorative issue to mark the 100th anniversary of the first powered flight, including
*essays by experts on the Wright brothers
*features on all 100 years of aviation history
*a bonus Air & Space guide to 2003 events.

ON THE WEB SITE

www.airspacemag.com

The centennial of the Wright brothers' first powered flight on December 17, 1903, has inspired so many exhibits, publications, and airshows that several organizations have devoted all their time to tracking the activities. Link to their sites for a preview of the year ahead.

CAROLINE SHEEN

Ken Hyde is building one of several Flyer *replicas that will take off in 2003.*

Airfairs

Many of the plans to celebrate the 100th anniversary of the Wright brothers' 12-second ascent into history in 1903, such as the Aviation World's Fair in Virginia next spring, recall earlier celebrations of aviation progress—in particular the 1910 Los Angeles International Air Meet.

Curiously, the Wrights' achievement on North Carolina's Outer Banks did not put the United States into a dominant position among developers of airplanes. As the National Air and Space Museum's Donald Lopez wrote in *Aviation: A Smithsonian Guide*, "European designers and pilots completely outclassed the Americans at the first international air meet, held at Rheims, France, in August 1909. Even though Glenn Curtiss [of the U.S.] won the prize for speed, all other prizes went to the Europeans. Of the 22 participating aviators, most were French."

Once back home, Curtiss joined with other promotion-minded fliers like Charles Willard and Roy Knabenshue to put together an American event to claim some of the glory—and have another shot at the prize money. In four months, the group lined up a site—Dominguez Field in southern California—arranged for pioneer pilots to appear, initiated publicity, erected grandstands, and beefed up the passenger platform at a nearby railroad station in anticipation of the crowds.

During 10 days in January 1910, some 226,000 spectators watched pilots like Curtiss, Willard, Knabenshue, Lincoln Beachey, and Charles Hamilton put their machines through record-setting paces. Ironically, the star attraction was Frenchman Louis Paulhan, who brought two Blériot monoplanes and two Farman biplanes. At the air meet, Paulhan set an altitude record (4,164 feet) and an endurance record (64 miles in 1 hour, 49 minutes, 40 seconds). Curtiss, in a biplane of his own design, also garnered some prize money: for speed with a passenger (55 mph) and for the quickest start (6.4 seconds covering 98 feet).

Although no records are likely to be set at the 2003 Aviation World's Fair, scheduled for April 7 to 27 at Virginia's Newport News/Williamsburg International Airport, several record-setters will appear. The oldest aircraft still flying in the United States, a 1909 Blériot XI from Old Rhinebeck Aerodrome, will fly when conditions allow. Louis Blériot flew a similar model across the English Channel on July 25, 1909, becoming the first person to fly long-distance over open water.

A replica of another craft designed early enough to have flown at the 1910 air meet, a 1909 Demoiselle, will also attend. Designed by Alberto Santos-Dumont, the Demoiselle holds the record for best nickname: "infuriated grasshopper." Other replicas planned are a 1911 Curtiss Pusher Model D, 1917 Sopwith Camel, Fokker D.R. 1, SPAD VII, Albatros D.Va, and 1918 Vickers Vimy. A 1903 Wright *Flyer* replica will fly daily.

It's a shame the Wrights themselves won't be on hand for all the celebrations of their achievements next year, but then they didn't attend the 1910 event either. They were in court trying to stop Glenn Curtiss and other designers from infringing on their patents.

—*Stuart Nixon*

Moments & Milestones is produced in association with the National Aeronautic Association. Visit the NAA Web site at www.naa-usa.org *or call (703) 527-0226.*

LOGBOOK

Nominations

Nominations will be accepted for the Frank G. Brewer Trophy, which is awarded annually to an individual, a group, or an organization for significant contributions of enduring value to aerospace education in the United States. Nominations will be accepted through January 10, 2003.

Nominations for the Robert J. Collier Award will be accepted from November 1, 2002 until January 31, 2003. The Collier is awarded annually for the greatest achievement in aeronautics or astronautics in America, with respect to improving the performance, efficiency, and safety of air and space vehicles, the value of which has been thoroughly demonstrated by actual use during the preceding year.

Events

The annual NAA Fall Awards Dinner will be held on October 21, 2002, in Washington, D.C. Awards to be presented will include the Elder Statesman of Aviation Award, the Katherine and Marjorie Stinson Award for Achievement, the Cliff Henderson Award for Achievement, and the Clarence M. Mackay Award. Various record holders will also be present. Visit *www.naa-usa.org* for more information, or call (800) 644-9777.

Rollout

Eclipse Aviation presented its E500 business jet to the public in a rollout ceremony in Albuquerque, New Mexico, last July 13. In development for three years, the E500 is a six-place jet that will cruise at 400 mph with a range of 1,500 miles, powered by two 85-pound Williams EJ22 turbofan engines—all for $855,000. Industry skeptics say there's no way a bizjet can sell for under a million dollars—too risky a business venture—but Eclipse president Vern Raburn says, "If you're not taking risk, you're not moving forward." The company expects to be producing 1,000 aircraft a year by 2007.

ALLEN AIRWAYS FLYING MUSEUM, WILLIS M. ALLEN, JR. COLLECTION